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Heating · Piping and Air Conditioning

December, 1929

Articles on

Heating—
By C. H. B. HOTCHKISS
and N. D. ADAMS

Piping—
By T. H. REA *and*
F. W. GREVE

Air Conditioning—
By W. L. FLEISHER
and PERRY WEST

Journal Section
of A. S. H. V. E.

Heating·Piping
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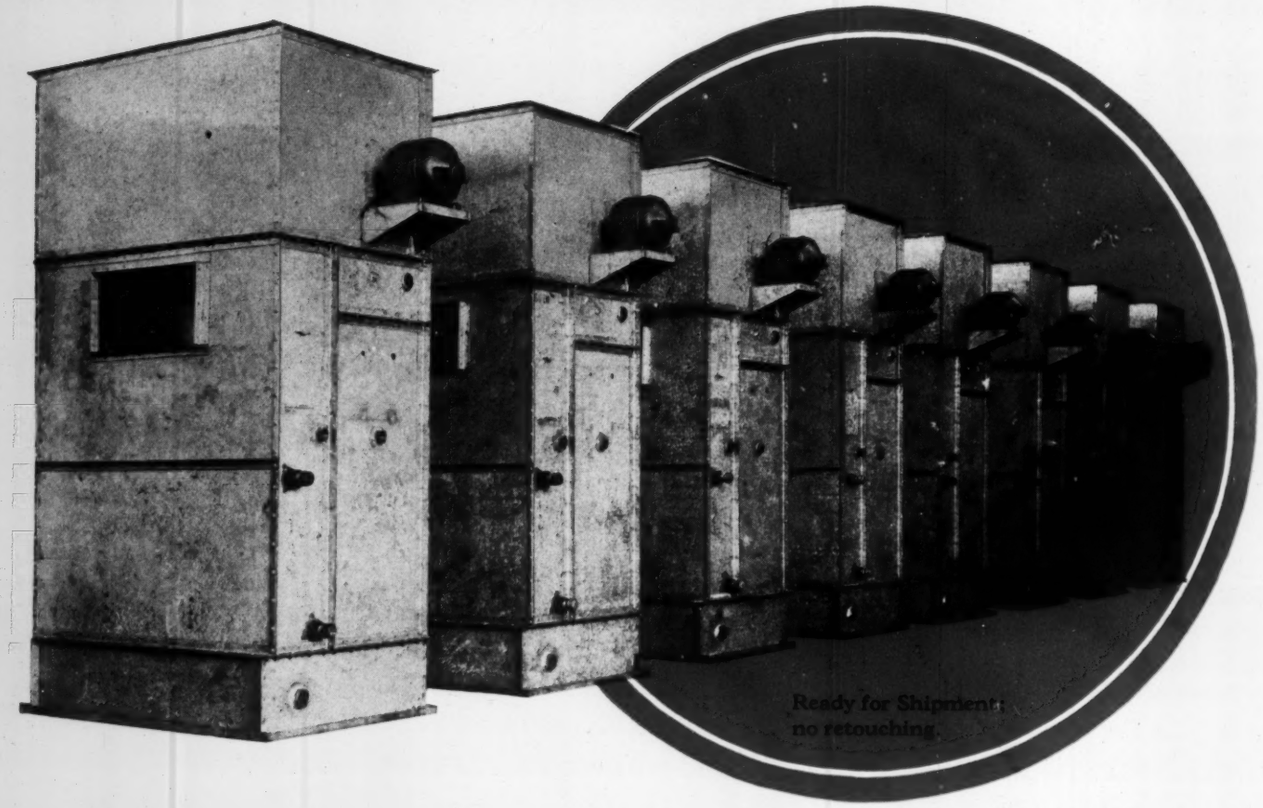

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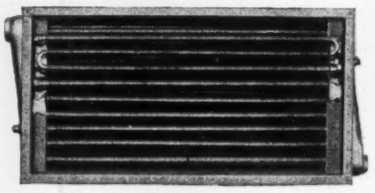

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The EDITOR'S PAGE

Heating · Piping and Air Conditioning

Bread Like Mother Tried to Make

Air Conditioning and Refrigerating Large Bakeries, by Walter L. Fleisher, is the title of the lead-off article in this issue of HEATING, PIPING AND AIR CONDITIONING. It is the first of a series which this author has prepared on the subject, and which will be published in this magazine.

Each loaf of bread, just as each unit of any product, must be of uniform quality in this age of quantity production and wide distribution. Everything entering into the manufacture of bread is affected more or less by temperature and moisture. It is safe to say that the modern baker could not prosper without air conditioning; with competing brands available in one store, each manufacturer must present a loaf unvarying, day after day, in quality. The results achieved, and the methods of accomplishing these results, by modern air conditioning as described in Mr. Fleisher's articles will be of great interest to any executive concerned with the production of uniform goods from hygroscopic materials.

The author has had a wide experience in heating, refrigerating and air conditioning engineering. His service on many committees of the *American Society of Heating and Ventilating Engineers*, the *American Society of Mechanical Engineers*, the *American Gas Association* and various commissions marks him as an authority.

Information on Steam Traps

Designing, operating, installing and maintenance engineers connected with steam piping work are vitally interested in the proper performance of steam traps. Steam traps, like any other piece of mechanical equipment, are designed and built to perform a specific function.

T. H. Rea, authority on traps, will cover a number of points concerning these devices in HEATING, PIPING AND AIR CONDITIONING.

Information on such factors as trap capacity, trap sizes, trap troubles, etc., has, in too many cases, been unavailable or incomplete. Mr. Rea will clear up several of these important points rather than present a complete treatise on traps.

INDEX FOR VOLUME I, MAY THROUGH DECEMBER, IN THIS ISSUE

This publication receives many inquiries from engineers connected with industrial plants, schools, office buildings, hospitals, hotels, etc., asking for information to supplement material published in this magazine in order that the technical data already presented to the heating, piping and air conditioning fields may be applied to various specific plants or structures. Because this information is so widely used, the index appearing in this number will undoubtedy prove of great benefit to consulting, installing, operating, and maintenance engineers.

The articles published in Volume I are indexed in abstract form, after careful study by our editorial department. A recent inquiry as to methods of keeping information available in offices revealed widely varying practices. Some prefer to file the complete publication under a certain heading; others prefer to preserve only those pages in which they are particularly interested.

The abstract form should meet the needs of any system of keeping technical material readily available; one method would be to clip each item, paste it on a card, and file the card under a suitable division. Thus, it would be necessary to keep only those pages which appeared to be the most valuable. An index of this sort is useful even when a complete copy of each issue is not kept, which is not the case with the common alphabetical form. We trust that this way of making our technical material easily found will fill the needs of all of our readers.

Heating the Office Building

We understand that medieval buildings were constructed of walls so thick that enough heat was absorbed during the summer to heat the structure throughout the winter months.

Perhaps this method did prove satisfactory; undoubtedly the occupants of the first office building were not provided the comfortable conditions enjoyed by the workers in today's great skyscrapers.

New office buildings are described and pictured in every issue of HEATING, PIPING AND AIR CONDITIONING.

Controlling Indoor Atmosphere

Would air conditioning improve the quantity and quality of your product? Do you require ventilation, and if so, where and of what character? What temperature, air motion, and humidity would best suit the requirements of your plant.

Perry West, consulting engineer and known widely as an air conditioning expert, answers the above questions (and many more) in several papers prepared for HEATING, PIPING AND AIR CONDITIONING.

The first article of the group appears in this number, under the title "Controlled Indoor Atmosphere—High Lights of its Development."

The Trends in District Heating

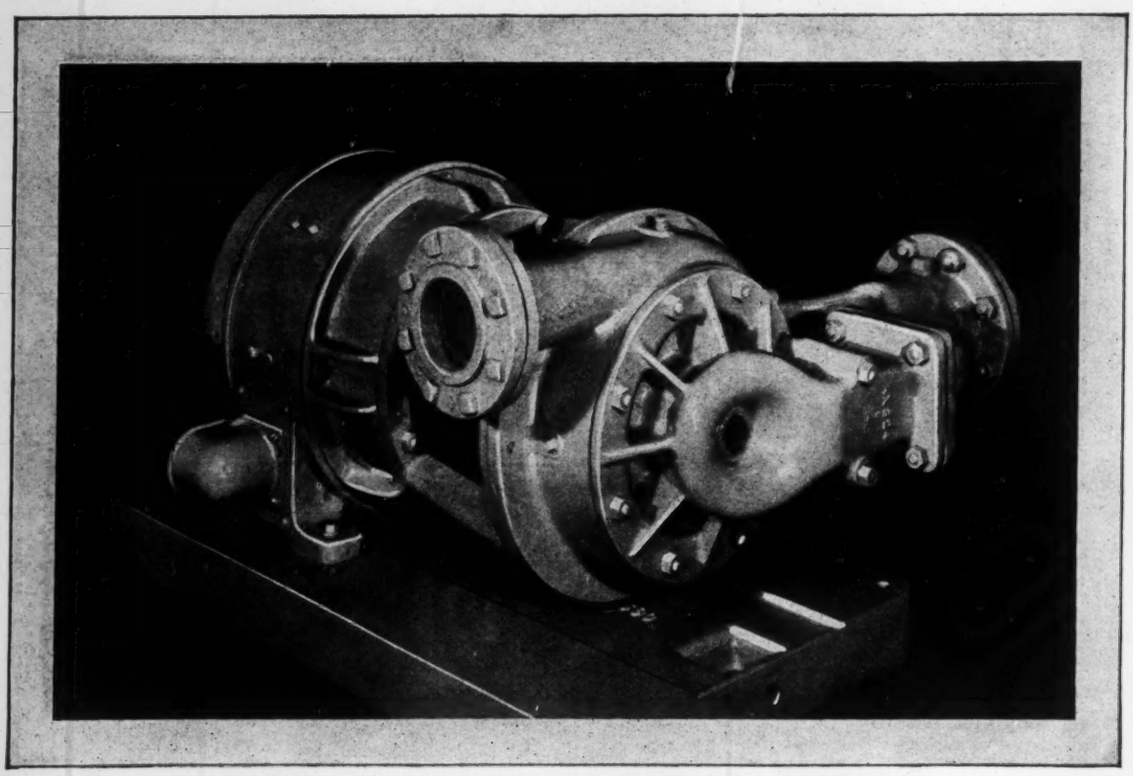
The first central heating plant started operating in the seventies. Early plants were for heating purposes only; later on the relationship of central heating to electrical power generation was realized. Such combinations have caused several trends in this form of heating, traced by Prof. C. H. B. Hotchkiss in this issue.

Low Humidity Drying

In electrical work, insulation is an important factor. In the low potential field, it is especially important as a small loss of power represents a considerable percentage of the total power. Outstanding examples of this field are the telephone and radio industries and the manufacture of apparatus for testing purposes.

The article on Improved Electrical Characteristics by Drying discusses the factors that affect electrical characteristics and the effect of moisture on telephone cables. Later papers will go further into the subject.

Drying by Vacuum will also prove interesting to engineers concerned with low humidity work. In this article the equipment and principles of vacuum driers are described. Especial attention is given to multiple-effect driers.



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Heating · Piping and Air Conditioning

Vol. I December, 1929 No. 8

Air Conditioning and Refrigerating Large Bakeries

By Walter L. Fleisher

IN ONE of my previous articles I mentioned the fact that air conditioning in the bakery is the oldest application of modern air conditioning recorded in any of our histories of industry. Fermented doughs are peculiarly susceptible to temperature and humidity. These not only affect the quality and size of the finished product, changing the structure and appearance of the loaf, but they also materially affect the time necessary for the various stages of bread making.

Before the days of uniform size and quality, before the time when sanitary codes required bread wrapping, and before the time when bread was produced on a quantity basis against highly competitive, far-reaching routes, where the large manufacturer with swift fleets of automobiles could encroach upon territories 50 to 100 miles from the seat of his production, modern air conditioning was not so essential to the baker as it is today. With the possibility of obtaining bread from many different bakers in one central store, it is very essential, when he has once satisfied the taste of the public, that the manufacturer should continue to produce the same loaf, exact not only in appearance but in quality, without change or interruption, day after day,—unless he wants to lose his fickle customers.

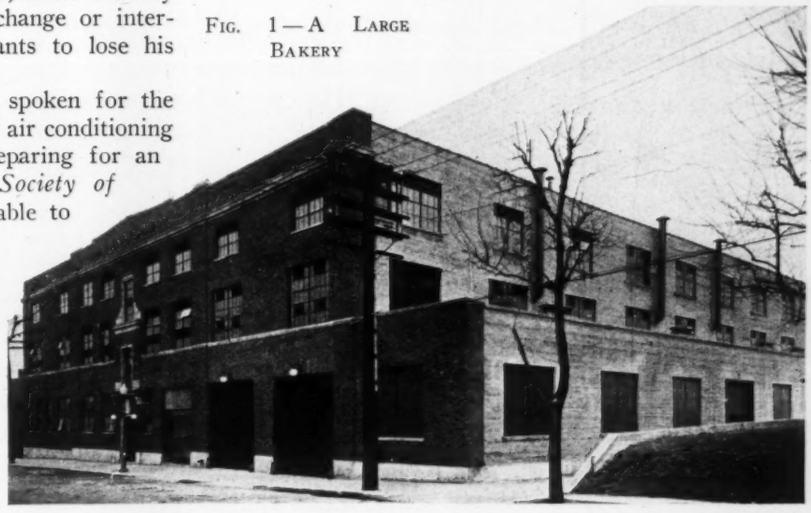
For many years I have written and spoken for the baking industry on the various phases of air conditioning as applied to that business, and in preparing for an address made before the *American Society of Bakery Engineers* last March, I was able to analyze the baking situation to show some very interesting reasons for the advantages and necessity of uniform temperature and relative humidity throughout the bakery.

In speaking to the *American Society of Bakery Engineers,* I was able to start without all of the preliminaries which I think are essential to an article of this kind addressed to a varied group not so familiar with the technique of the bakery. I therefore feel that before I stress the needs and advantages of a particular type of air conditioning for the bakery, I should give my readers a general idea of the ingredients and processes entering into the manufacture of bread.

Ingredients and Processes Used in Bread Baking

The basic components of all bread are flour and water, in which the flour is about 60 per cent by weight and water 40 per cent. To these two ingredients are added seasoning, flavoring, and a fermenting element, today almost universally yeast. Besides yeast there is salt and sugar (the quantity of sugar affecting the toasting quality of the bread), usually milk in white bread, and sometimes butter fats in very small quantities. The loaf itself is affected not only by the quantity of water that is added, but also by the quantity of water which is hygroscopically inherent in the ingredients themselves. The flour, for instance, contains hygroscopically for its best operation from 13 to 15 per cent of moisture by weight,

FIG. 1—A LARGE BAKERY



and the sugar, salt, and yeast are all water-holding, to even up or unbalance the final product. Everything entering into bread making is affected more or less by the temperature and relative humidity of the surrounding atmosphere. The ideal condition for a bread manufacturing plant, therefore, would be a wholly conditioned plant, from flour storage to finished product storage; and although this is a result to be wished for, up to the present time I believe that no steps have been taken, farther than the conditioning of two or three departments and the circulation of air in other departments, to maintain a nearly ideal condition.

FIG. 2—FLOUR STORAGE DEPARTMENT ON THIRD FLOOR—NOTE BAGS OFF FLOOR TO ALLOW CIRCULATION OF AIR

Normal Regain of Ingredients and of the Finished Loaf

I have stated that in an investigation of the bread industry a number of very interesting things were discovered; these have to do with the normal regain of the ingredients entering into the manufacture of bread, and the normal regain of the finished loaf. Regain in most hygroscopic material is dependent upon the relative humidity rather than upon the dry bulb temperature. In other words, the vapor pressure of the moisture in the atmosphere and the vapor tension in the material itself reach a point of equilibrium, when not affected by too high an air velocity, at a definite relative humidity, and the variation from these conditions will set up a transfer of vapor from the air to the material, or the material to the air at all times, unless the material itself is made impervious to such reactions by being sealed in some container or within an impervious crust.

Bread, however, and its ingredients, due to the action of fermentation, is susceptible also to dry bulb temperatures. Consequently, knowing the condition of normal regain and knowing the dry bulb temperatures that give the best results, it is a simple matter to work out the psychrometric condition essential to the proper carrying on of the baking business.

Ingredients Require Relative Humidity Different from Finished Loaf

In my investigations of the bakery, I discovered that the relative humidity required for normal regain was the same for flour in storage, ingredient mixing, fermentation, and proofing; but that after baking, a structural change took place which created a new condition of regain which corresponded to a different relative humidity. Therefore the cooling of the loaf, its wrapping, and the maintenance of the loaf in proper condition was at a different point on a curve of regain from the balance of the process.

This is a very interesting point, in fact, one of the most interesting points in the whole engineering of a bakery, and seemingly from the reception that it received, it is a new idea—but new simply from the fact that regain and its relation to a definite relative humidity is not understood. Nor is the relationship between dry bulb and relative humidity understood by the average engineer or layman. To illustrate my theory, which is borne out by practice, flour maintains its hygroscopic moisture content, and seems to function best, at a temperature of 75 deg., and 68 deg. wet bulb, which is approximately 70 per cent relative humidity. The mixing of the ingredients which usually takes place in the fermentation room, and the fermentation room itself, are at their best conditions at 80 deg. with a 75 deg. wet bulb. This is again 70 per cent relative humidity. When the doughs come out of the fermentation room, they go through a process of scaling, dividing, rounding, and dry proofing, and from that department into the final proofer, in which proofer the best condition is 95 deg. with an 86 deg. wet bulb, which is also 70 per cent relative humidity. It is obvious that if these conditions through many years have proved to be the most satisfactory, probably an intermediate point for the make-up department—that is, the department where scaling, dividing, rounding, and rest take place—would be an intermediate point between the fermentation room and the proof box, of say 85 deg. with a 78 deg. wet bulb, or again, a 70 per cent relative humidity.

When bread is removed from the final proofer, it is immediately put into the oven, where the initial temperature is about 450 deg. This temperature does two things: it kills the yeast spores and stops fermentation; it changes the structure of the gluten and it drives off a certain amount of moisture—about 10 per cent. This moisture is never regained without destroying the character of the loaf, and when the loaf is brought down to its final temperature, which may be room temperature, or 75 deg., a 66 deg. wet bulb, or a 60 per cent relative humidity seems to be the best condition for its final equilibrium.

Storage of Bread Baking Supplies

As was stated before, bread and its ingredients are peculiarly susceptible to temperature conditions as well as to moisture conditions, and as living organisms enter into the manufacture of bread, cleanliness and the absence of foreign matter, fungus or bacteria is essential to the manufacturing plant. As bread in large manufacturing plants requires a very large quantity of raw materials, and as these materials can be bought much more cheaply in bulk, the storage of these under proper conditions is very essential to the quality of the loaf. The flour, which is bought in carload lots, either dries out or takes on moisture, and under conditions which main-

tain the proper hygroscopic regain in the flour, it is highly susceptible to mould. It is, therefore, always a question in the mind of the manufacturer whether he should store his flour in the basement or on his top floor. The routing of his raw material through his factory would tend toward the storage of flour on the top floor, but as the top floor is often dry and hot, the loss in weight is likely to prejudice him towards basement storage. As basement storage is likely to be damp, the tendency towards the formation of mould in the basement is greater than on the top floor. In either case, circulation of air has a tendency to retard mould spores, and consequently a slight movement of air is essential in flour storage. If this movement, however, is of any appreciable velocity, drying out of the flour is likely to take place, entailing a change in the structure of the loaf, unless great care is taken.

Temperature of Cold Storage Room

The ingredients that enter into the making of a loaf of bread must be thoroughly mixed, so that absorption of the water is absolutely homogeneous and to the full extent of the gluten strength of the flour. Most of the ingredients outside of the flour itself are directly affected by temperatures above storage temperatures. Therefore, every bakery must maintain a cold storage room at approximately 60 deg. in which all ingredients except yeast and milk are stored.

The yeast, being more readily affected by heat than any other ingredient, requires a separate storage room, or refrigerator at a temperature of about 45 deg.

With the possibility of obtaining bread from many bakers in one central store it is very essential that the manufacturer should continue to produce the same loaf, exact not only in appearance but in quality, without change or interruption, day after day — unless he wants to lose his fickle customers

Refrigeration Essential

We are bringing out these points to illustrate the fact that the refrigeration, which we shall show later is essential to the proper air conditioning for bread, is only a part of the refrigeration required in a modern bakery, and that the increase in refrigeration to take care of air conditioning requirements is not introducing in itself a new element to the baker. As most of the modern bakeries are making cake in the same plant in which they are making bread, and as practically all of the ingredients entering into the manufacture of cakes or pies require refrigeration, the additional amount required for air conditioning is minimized still further by the normal storage requirements of a modern plant.

Maintenance of Proper Mixing Temperature

In the process of bread making, flours of different quality are blended in conveyors and sifters to produce the type of flour required for the particular loaf in the particular bakery. The flour and the other ingredients such as yeast, salt, sugar, shortening, etc., are then mixed with water in a kneader or mixer. This mixing, which is one of the most important processes in a bakery, is done in what is called a high speed mixer, which consists of a bowl in which steel arms revolve at a definite speed. In the modern high speed mixer, about 60 r.p.m. is considered an average speed. As the gluten under the effect of the liquids starts to expand and absorb the water, a very great resistance to the mixing process is encountered, requiring for a 5-barrel mixer about a 40 h.p. motor to operate. This creates a very large amount of heat in the dough, and as the elasticity of the gluten or its absorption becomes lessened at a temperature above 80 deg., the mixing process must be stopped at that point. As with our high speed mixer it takes from 10 to 15 minutes to get a homogeneous dough with full absorption of water, artificial steps must be taken to keep the temperature of the mix down to 80 deg. or below during this period. As the flour is introduced into the mixture at its room temperature, say 70 to 75 deg.—and incidentally, this is one of the reasons for storing flour in the basement in order to keep its temperature at this point—the 40 h.p. required to operate the mixer which is dissipated as heat inside the bowl, would raise the mix to above its critical temperature of 80 deg. in three or four minutes, if the water which was introduced was not at a very low temperature. It is therefore customary in all of the modern bakeries to refrigerate the water which enters into the ingredients to a temperature of 40 deg. or less, so that the mixing may continue during the necessary period without the dough rising in temperature above the critical temperature of 80 deg.

Three Cooling Expedients Which May Be Used

This cooling of the water, particularly in the summer time, is one of the main requirements of the baker's refrigerating system. However, the quantity of water which is introduced is definitely fixed, and if water at 40 deg. in rising to 80 deg. does not give enough cooling effect to cover the time period essential for mixing, one of three additional expedients must be resorted to: (1) either ice must be introduced into the bowl of the mixture and the quantity of ice very carefully weighed so that this much water may be subtracted from the amount put into the ingredients, or (2) the bowl of the mixer must be water-jacketed and refrigerated water put in the jacket, or (3) cold air supplied by the air conditioning system must be introduced into the bowl of the mixer.

The introduction of the cold air, which is a problem for the air conditioning engineer, serves two functions: one is to lengthen the time of mix, and the second is to aerate the bread. There is no doubt that the introduction of cold air into the mixture gives a finer loaf and a whiter loaf, but the first cost of mixer cooling apparatus and the amount of refrigeration required for this purpose have been two of the drawbacks to its general use. The reason for this is that unless the air is introduced at a temperature of about 30 deg. it is hardly worthwhile because the quantity of air that can be introduced without blowing the flour out of the mixer is not great, and for the quantity of air that can be put in to be effective, it must be low in temperature. The water that is circulated in the jackets is approximately of the same tem-

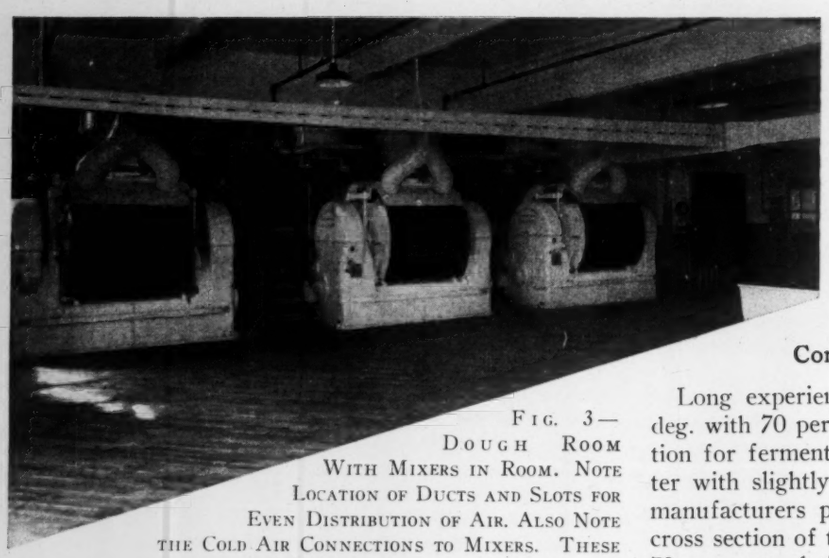


FIG. 3—DOUGH ROOM WITH MIXERS IN ROOM. NOTE LOCATION OF DUCTS AND SLOTS FOR EVEN DISTRIBUTION OF AIR. ALSO NOTE THE COLD AIR CONNECTIONS TO MIXERS. THESE ARE 5-BBL. MIXERS

perature as the dew point of the fermentation room, and consequently the fermentation room air conditioning equipment can be increased to take care of the cooling of the jackets.

When it is realized that the cooling of water for ingredient purposes, the cooling of the jacket water, and cool air for the mixers takes considerably more refrigeration than all of the rest of the requirements of a bakery, the reason it is not used universally can be appreciated.

Calculations for Refrigeration Requirements

The calculations for refrigeration requirements for storage and mixer purposes in a bakery are not difficult. Each pound of water that enters into the ingredients of a dough would normally, in the summer time, have to be brought down from the average temperature of city water to 40 deg. Therefore, for each pound of water, perhaps as many as 40 heat units would have to be removed, over whatever period this water was used. To give a more concrete example: the average 5-bbl. mixer requires approximately 450 lb. of water and is used for a 20-minute period; in other words, on an average, 22 lb. of water a minute for a mixer of this size would require approximately the equivalent of four tons of refrigeration. If the water could be stored up between periods in an insulated tank, the refrigeration requirements, of course, could be cut down. The refrigeration requirements for jacket cooling water are less than those for ingredient water, and will average about 2 tons as against the 4-ton requirement for ingredients. However, if cold air is introduced into the mixer, an additional 6 to 9 tons of refrigeration must be added, making the requirements for a 5-bbl. plant as much as from 12 to 15 tons, without taking into consideration the storage rooms, which would add another two to three tons to such a plant.

Ventilation of the Dough Room

The ventilation of the dough room is of great interest to the air conditioning engineer. It is also of great interest to the baker, for in this room the yeast does its principal work, and the gases released in fermentation, work best under definite temperature conditions. However, the relative humidity is of scarcely less importance than the temperature in that it prevents the formation of hard skins on the doughs while they rest in their troughs, and allows the fermentation process to take place normally over the entire surface of the doughs, and the doughs to maintain their normal regain; i. e., the minimum loss in weight takes place with the correct relative humidity.

Conditions Suitable for Fermentation

Long experience has indicated to the baker that 80 deg. with 70 per cent relative humidity is a good condition for fermentation. Certain classes of flour are better with slightly lower temperatures, and certain bread manufacturers prefer higher relative humidities, but a cross section of the industry would indicate 80 deg. with 70 per cent relative humidity. This is an ideal condition for the air conditioning engineer to maintain, but it involves calculations of both humidifying and dehumidifying, fresh air and recirculation, which are of great interest. Not only that, but the design of the distributing duct work for the introduction of the proper air in a fermentation room is extremely important, as even with other conditions maintained as desired, any drafts across the surface of the doughs create what are known as skins, which counteract the beneficial effect of the conditioning. In order that the fermentation room may be maintained at its proper conditions, with a minimum amount of air circulation, all fermentation rooms should be thoroughly insulated.

Exact Conditions Must Be Maintained in Dough Room

As a concrete example of dough room conditioning, remember that the conditions to be maintained are 80 deg. and 70 per cent relative humidity, and this is one of the cases where the conditions desired are not approximate. If a baker knows what he wants in order to produce a definite result, a variation of 2 deg. dry bulb and 2 per cent to 4 per cent relative humidity will mean a great difference in his finished product. It is not the same as in conditioning for comfort where a lower condition than that guaranteed may in some cases, mean even greater satisfaction to the purchaser. The control of the conditions must be exact and steam and refrigeration must both be available at all times to insure uniform results. Eighty-degree dry bulb and 70 per cent relative humidity mean 73 deg. wet bulb and 69 deg. dew point and the air must be introduced into the room at a point just low enough in dry bulb temperature and at 69 deg. dew point to maintain these conditions.

Bear in mind that an air washer will saturate air at the temperature of the entering wet bulb and then visualize the problem of the air conditioning engineer who has in mind the production of results at a maximum economy of operation. He can return most of the air from the dough room at 73 deg. wet bulb and add enough cold water to bring it down to the correct dew point of 69 deg. But, supposing outside conditions were below 73 deg. wet bulb, it would be better to take air from outdoors than to return the air from the room,

and this must be done automatically, and, when it is done, air in the room must be automatically released to the outside atmosphere, and the water temperature must be kept always at a point so that the leaving condition of the air is 69 deg. dew point. The air is leaving the washer at 69 deg. saturated, so that if the heat inflow from walls, ceilings, fermentations, etc., is not enough to raise this air of 69 deg. to 80 deg. dry bulb, then less air must be introduced or steam utilized to obtain the required equilibrium. Whenever the outside wet bulb is above 69 deg. refrigeration must be used, unless of course, sufficient water well below 69 deg. is available. As economy of pumping calls for a heat transfer from 7 to 9 degrees in the washer, 60 deg. water is about the maximum to give economy of operation.

Otherwise it is probably better to use refrigeration and use the available water for condenser purposes.

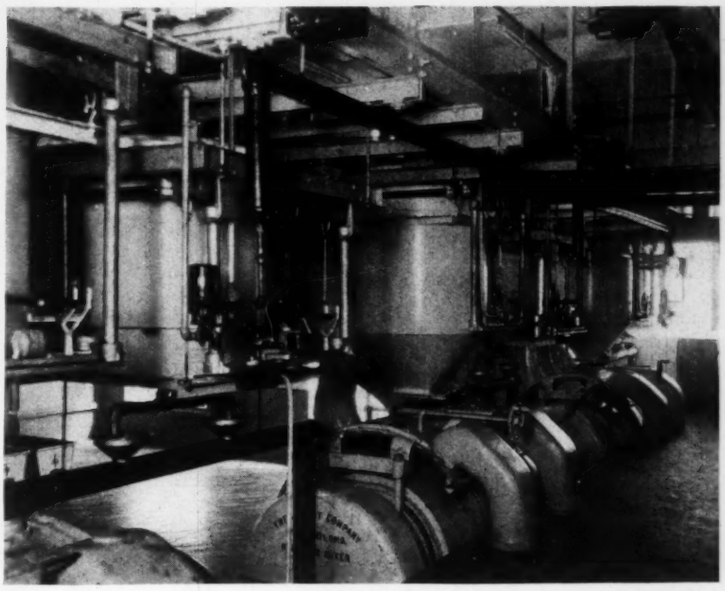


FIG. 4—MIXER PLATFORM WITH WATER WEIGHING APPARATUS AND COLD WATER CONNECTIONS TO JACKETS

Another Heat Balance Problem in Dough Room Conditioning

There is another extremely interesting heat balance problem in dough room conditioning; that is the use of the overflow water from the water chamber of the washer. As from 4 to 9 gallons of water per minute may overflow, and as its temperature is the saturation temperature of 69 deg. it may be better to return this water to the cooler to be brought down to whatever temperature is desired rather than to waste this water and bring other water of 80 deg. down to the required temperature. Of course one has against this saving the extra cost of equipment and the extra cost of pumping.

Placing of the Mixers

In the calculation of air conditioning requirements for the dough room, it is important to determine whether the mixers are to be placed in the dough room itself or in a separate room. This is because the loss of the mixer motors is transformed into sensible heat that flows into the room. In a dough room in which mixers are located this is the largest single item to be taken care of, even exceeding the heat in-flow through the roof. (The dough room is usually under the roof.)

In a 5-bbl. mixer requiring 40 hp. to operate, all of the 40 hp. turns into heat,—each horse power being the equivalent of 2545 B.t.u. per hour. Therefore 40x2545 =101,800 B.t.u. would be liberated per hour, of which 85 per cent or approximately 86,000 B.t.u. would go into the doughs and 15,000 B.t.u. into the room. This number of heat units would raise from 69 to 80 deg. over 1200 c.f.m. of air.

A Typical Dough Room Problem

It might be well at this time to give a concrete example of a dough room problem. In my recollection there are no bakeries employing 5-bbl. mixers that have not at least two mixers. A bakery of this size would have a fermentation room approximately 30 x 50 feet exclusive of the space occupied by the mixers themselves. The floor area during the fermentation period would practically completely be filled with troughs and would hold approximately 40 troughs. The troughs are metal containers ten to twelve feet long and about 18 inches wide and the same depth with rounded bottoms into which the doughs are allowed to flow from the mixers.

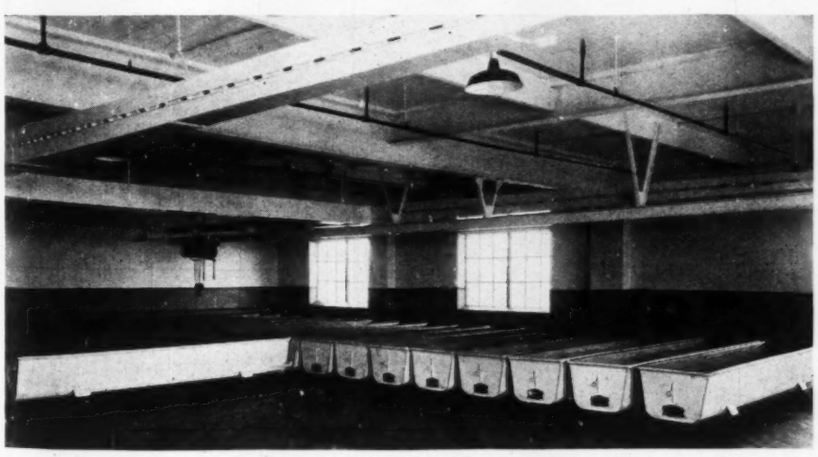


FIG. 5—DOUGH ROOM ON THIRD FLOOR WITH DOUGH TROUGHS AND AIR DISTRIBUTION PIPING. NOTE CORK INSULATION ON WALLS AND CEILING. THIS ROOM IS MAINTAINED AT 80 DEGREE DRY BULB

For many years it was customary to make these rooms 15 to 20 feet high. This was due primarily to the fact that the mixers themselves were always placed, or nearly always placed, in front of a platform on which the ingredients could be assembled for introduction into the mixer and the ingredient water cooled and weighed. After it

became more general to separate the mixer room itself from the fermentation room and to introduce proper air conditions into the fermentation room without the use of direct expansion refrigerating pipes, the fermentation room ceiling was brought down to approximately 8 or 10 feet. It made the room easier to insulate and easier to maintain at the proper condition.

Heat Transmission Figures for Ideal Dough Room

Therefore, taking the ideal room for air conditioning purposes say 30x50 feet, 10 feet high, insulated and having 9 double windows and assuming that two walls are interior walls and two walls exterior walls, the heat loss with 95 deg. outside and 80 deg. maintained inside would be 4,400 B.t.u. for the exterior walls, 3,000 for the exterior windows, 900 B.t.u. for the interior walls, 12,000 B.t.u. for the roof (assuming this room is under the roof) and 3,000 B.t.u. for the floor. Usually the oven room is under the floor of the fermentation room, causing more heat infiltration. This gives a total of 25,600 B.t.u. when 10 per cent for contingencies is added and the mixers are not in the room, which must be taken care of with air entering at 69 deg. We are assuming that the maximum outside wet bulb conditions with 95 deg. may be 78 deg. and as the maintained conditions in the room, as I have stated before, are 73 deg. wet bulb, it is wise under these maximum outside conditions to recirculate from the room as much air as possible. However, it is also well to bear in mind that the opening and closing of doors for the introduction of the troughs will allow quite a quantity of air to leak out and consequently the amount of recirculated air cannot be greater than the difference between two air changes of new air per hour and the total amount circulated. If in this particular room the mixers had been placed in the room itself, of course the room would undoubtedly have been larger, but the number of heat units from the inefficiency of the motors would have been, from our previous calculations, 15,000 B.t.u. per hour, had one mixer run all the time, or if two mixers had run one-half of the time each.

One can readily see, looking at the transmission losses tabulated above, what a large proportion of the total amount required this item can be.

Editorial Note: A second article by Walter F. Fleisher on air conditioning and refrigerating for large bakeries will appear in an early issue.

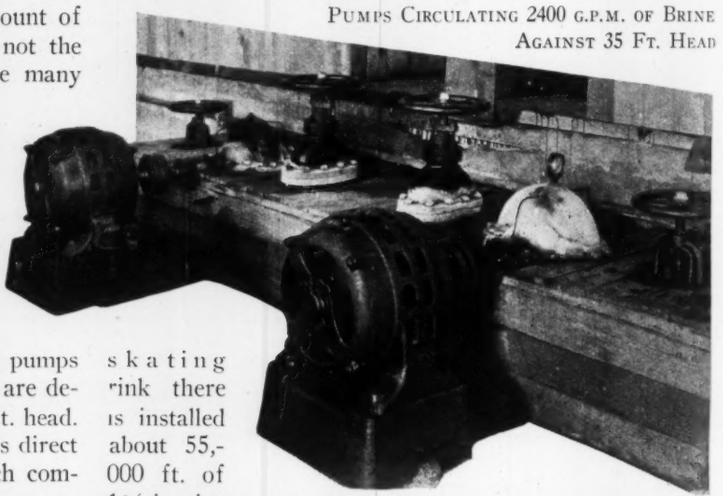
Refrigeration for Skating Rinks

SPORTS are commanding an increasing amount of attention from the American people and not the least of these is skating. Typical of the many rinks in this country is the Springfield Skating Arena, Springfield, Mass.

The important part of the skating rink, from the engineer's point of view, is the refrigeration equipment which is used in the production of the ice surface. In addition to the compressor equipment there must be ample pumping equipment for circulation.

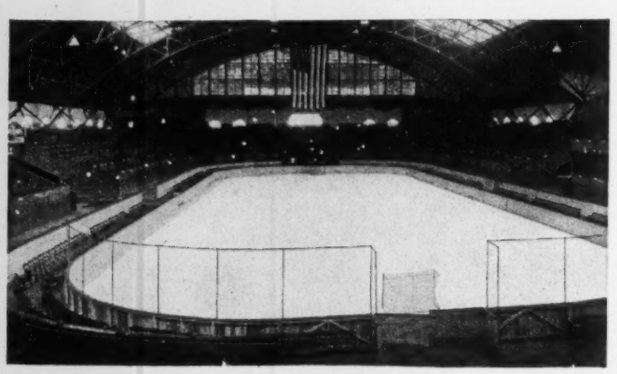
In the Springfield Skating Arena the brine pumping is handled by two 6-in. centrifugal pumps driven by 30 hp., 1800 r.p.m. motors. The units are designed to handle 700 to 900 g.p.m. against a 110-ft. head. The equipment includes two ammonia compressors direct connected to 100 hp. synchronous motors. Each compressor is rated at about 60 tons of refrigeration.

Calcium brine is taken by the centrifugal pump from a brine tank and pumped through a horizontal shell and tube brine cooler and thence to the floor of the skating rink about 200 ft. away. On the floor of the skating rink there is installed about 55,000 ft. of 1¼-in. pipe laid on 4-in. centers. By a system of feed and return headers, one on each side of the rink, the brine is forced across the floor thus producing the refrigerating effect required to freeze the water on the floor. The pipes on the floor are laid in a patented construction made up of concrete with a terrazza finish. Copper strips are placed at regular intervals in the floor to allow for expansion and contraction due to changes of temperature.



Pumps Circulating 2400 g.p.m. of Brine Against 35 Ft. Head

The Skating Rink in Springfield, Mass.



When a new ice surface is laid on the floor, or when additional surface is built up, both pumps are required to carry on the freezing process. After the floor has been frozen and when the refrigerating equipment must hold a hard surface, only one pump is needed.

Another skating rink is the Boston Arena where an 8-in. centrifugal pump driven by a 40 hp., direct current, variable speed motor handles 1600 g.p.m. against a 65-ft. head.

Mechanical Equipment of the Mayo Clinic

By N. D. Adams

THE arrangement of equipment in any building is controlled by the planning of the interior. In order to achieve complete harmony between mechanical equipment, structure and planning of the Mayo Clinic a firm of architects having its own structural and engineering department was chosen. The realization of any large project is often the result of the planning and foresight of some individual who has a mental picture of the finished work and who possesses the ability to conceive each detail and direct the execution in perfect coordination. The Mayo Clinic was very fortunate to have such a man, Dr. Henry S. Plummer, chairman of the building committee.

Plan Developed Problems in Design of Equipment

(a) The arrangement of entrances from street and traffic tunnels into the building, location of admitting desk, connecting corridors, stairways, elevators, waiting rooms, and toilet rooms must be for the convenience and comfort of the public.

(b) The above must not interfere with the design of offices, examination rooms and laboratories, the location and layout of which must tend toward dispatch and efficiency in the work of doctor and assistant.

(c) The new structure must tie in with an existing building insofar that the circulation of the public, physicians, and records from one department to another shall flow in an unbroken cycle.

A plan thus conceived developed some very interesting problems in design of mechanical equipment. In working out these problems the use of standard makes and systems of equipment was held to as far as possible, but some new applications were permitted, a description of which may be of value to those who find it necessary to build without precedent. All who venture from the tried and proved have made, and will make, mistakes, but from them much may be learned.

Types of Service or Systems

The heating, ventilating and plumbing systems, with accessory services, must supply not only the exacting needs of the building occupants but must be designed for efficient operation and of materials which will give the lowest in maintenance costs. These services must be easily accessible, while the means of conveyances, such as pipes, ducts and conduits, must be concealed, yet also accessible. Their location must not interfere with the removal and relocation of room partitions, for design of an office or laboratory will change with the advance of the profession and the development of new equipment. Following are listed the services required:

The Various Services Required

Heating: The temperatures during our heating season are quite variable with an average for the eight months from September to May of 32 deg. fahr., with a low point of 30 deg. below zero. The heating system is designed for an even inside temperature of 70 deg., with the possibility of maintaining a higher or lower temperature in the examination rooms (range 65 deg. to 80 deg. fahr.).

Ventilation: All examining rooms, offices, laboratories, waiting rooms and clerical spaces are ventilated.

Plumbing: In addition to the usual public toilets for men and women on each floor, there must be toilets for the men and women members of the staff, drinking fountains in the public and private corridors, lavatories in each examining room and many special types of sinks and trimmings in the laboratories.

Accessory Service: In addition to the plumbing, heating and ventilation of each room, the following services must be provided or made accessible for future connection:

Medium pressure steam (40 to 50 gage).

Medium pressure steam condensate return.

Compressed air at 15 lb. for temperature control.

Compressed air at variable pressures for laboratory work.

Soap dispensing system.

Medical men's consulting room call (sectional).

General ticker call system (this is intersectional for surgeons, sectional for medical men).

Room signal system (for use of desk clerk in section to designate which examination rooms are being used).

Chime call system (for calling general office men, engineers or others whose duties make it necessary for them to be located at any time in any part of the building).

Appointment desk and departmental load indication (this equipment facilitates the making of appointments

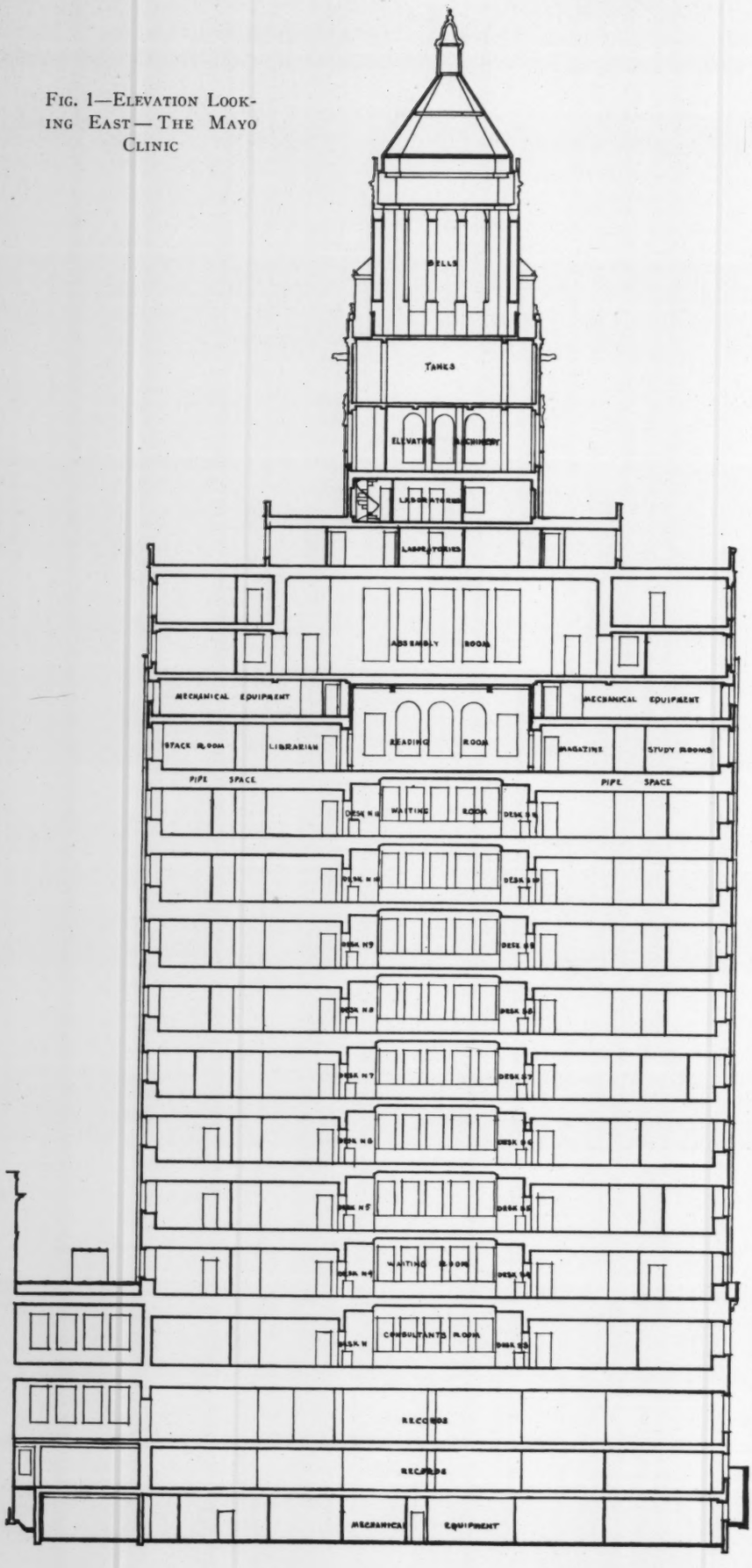


FIG. 1—ELEVATION LOOKING EAST—THE MAYO CLINIC

between departments, thus equalizing the work to be done).

Elevation

By referring to the cross section, Fig. 1, we not only see the utility of each floor but find that the work wherein the public comes into contact with the doctors is confined between the third and eleventh floors, inclusive, with the Mayo medical library on the twelfth. The Mayo Foundation with offices, class rooms and assembly hall occupies the fourteenth and fifteenth floors.

Ceiling Space

A furred ceiling space is to be noted over each floor from the first and including the eleventh. Here are installed all horizontal pipes, ducts, etc., required for the floor above. The basement and thirteenth floor house the major portions of mechanical equipment with the elevator machines on the eighteenth and the water storage tanks on the nineteenth.

Typical Floor Plan

A typical floor plan will illustrate the way in which some of these problems were handled. (See Fig. 2.) The offices are located symmetrically on either side of the waiting rooms and service sections. It will be noted that the toilets, janitors' closets, main stairway and elevators form one central group, while the two service stairways, vertical ducts and cable ways occupy a bay on each side of the waiting room. Clerical space, vertical shafts and staff toilets on either side occupy the remainder of what is commonly called "dark area" or "unlighted space." Thus, practically all of the outside wall or daylight area was made available for offices, examination rooms and laboratories.

Vertical Pipe Shafts

Further inspection of the plan will show the similar room arrangement on each side. It will be noted that the width of all rooms is equal to one-half of each bay with the dividing partition meeting a furred pipe space between each pair of columns. The width of the pipe shaft is equal to the width necessary for furring the largest columns on the lower floors and is carried

through at the same dimension up to the thirteenth floor pipe space. The horizontal space between the column and pipe space is occupied below the window sill by the concealed combined heating and ventilating cabinet.

Note also that there are no interior vertical shafts and only one column on each side which would interfere with any rearrangement of the office space.

Problems in Construction and Pipe Arrangement

Some interesting problems were met in the building construction and pipe arrangement. The floor construction is of reinforced concrete, pan type, with joist running parallel with the outside walls. This leaves a space one pan width next to the beam which supports the wall. In order to prevent side movement of the wall beam, two tie rods were used at the third points perpendicular to the joists.

The arrangement of the pipes had to be such that the connections to radiators, laboratories and other equipment could be made without interference of one pipe with another.

To maintain the predetermined spacing, a ⅜-in. steel plate was drilled and set at each floor level. These plates were made to carry the vertical loads of the pipes at every three or four floors for services of constant temperature and at anchor points for lines where expansion occurs. This load is transmitted through a coupling, flanged union, or bar clamp placed directly above the plate.

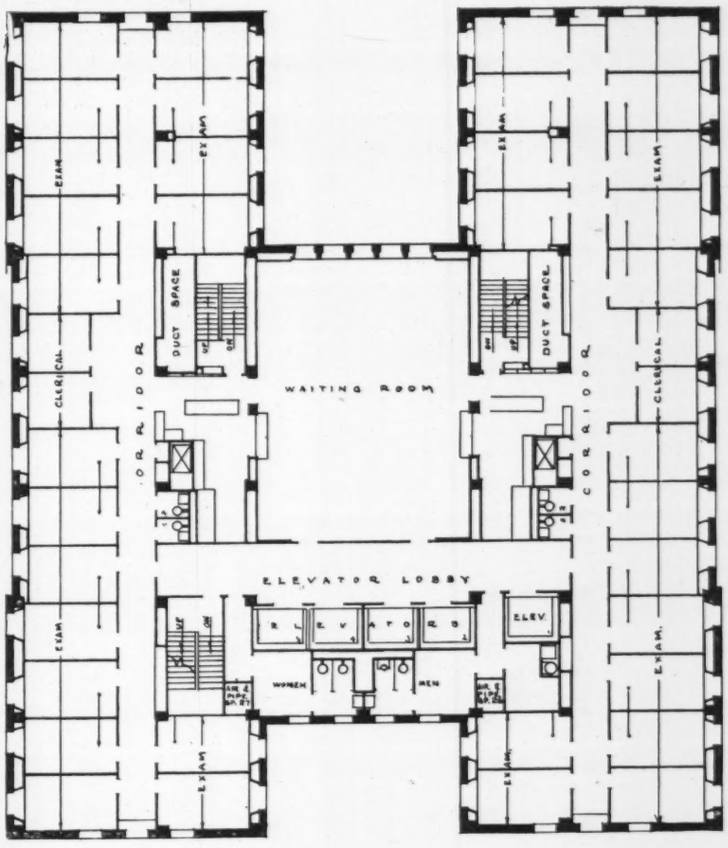


FIG. 2—A TYPICAL FLOOR PLAN

Connections to all fixtures were made with three elbows to allow for movement in the riser or for ease in adjustment of height in setting the equipment.

Extra tees were installed in each service for future connections at six of the twenty-two pipe shafts, uniformly distributed. They were located just below the floor slabs, accessible from the ceiling space, making it very convenient to run connections to any place on the floor above. They were stopped with a cast brass plug, or a nipple and cap, for ease of removal.

Stop at Each Floor Prevents Air Movement

After all the vertical piping had been run and tested, radiators set and duct connections made, the remaining open space at each floor was closed with metal lath and plaster. This formed a stop at each floor to prevent air movement from ceiling to ceiling and up along the outside walls. Wherever a furred space presented a possibility for a continuous shaft, although not needed at present, floor openings were left with a 2-in. slab and access panels installed in the partition construction.

The Heating System

It was decided to use a vacuum return line heating system. A study of pipe sizes, expansion in risers with methods of taking care of same and the desire to eliminate all possible horizontal piping in ceiling spaces led to a design with supply mains on the thirteenth floor, drop supply risers continuing to the basement ceiling with drip mains trapped to the return. The radiation on the fourteenth and fifteenth floors is fed by up-feed risers, while a separate main riser with overhead branches on the eighteenth floor supplies the tower section. A system of returns originating at the top radiators drops parallel with the feed risers and enters a system of main returns on the basement ceiling, which discharges directly into the vacuum receiving tank.

All pipe sizes are based on a given pressure drop with the maximum flow of steam required by the radiation supplied by each branch main or riser.

To maintain a minimum vertical movement of the risers at each floor, a swing connection was made to the mains in the basement and thirteenth floors with anchors on the thirteenth and second floors and a loop expansion fitting swing out in the ceiling spaces on the sixth and seventh floors.

Expansion Loops

The ceiling spaces afforded an unusual opportunity for concealing the expansion fittings and for making a good job. The loops were shop bent and in a full circle with a 4-in. to 6-in. pitch to allow for compression. The diameter was figured on manufacturers' standards for pipe sizes equal to the risers and sufficient to give the movement needed. For example, pipe shaft No. 6 supply riser 2½-in. at twelfth floor decreases to 1-in. at the first floor. It is anchored at the twelfth and third floors with a 2-in. movement estimated between these points. The pipe size at the sixth floor ceiling is 1½-in. and a loop 2 ft. 6 in. in diameter was used. The ends of the

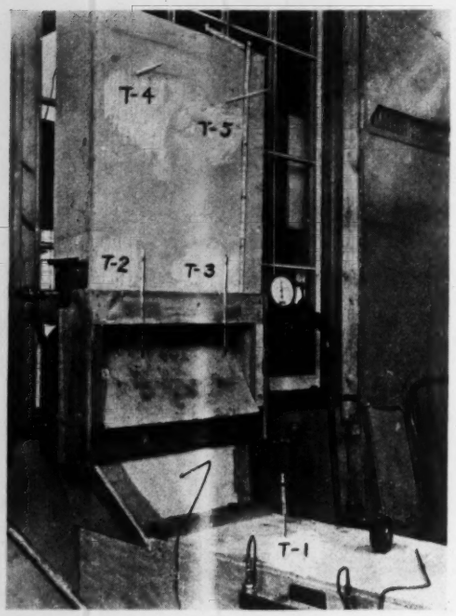


FIG. 3—THE SET-UP FOR TESTING COPPER RADIATION

loop were fitted with extra heavy malleable or steel union ells of ground joint type looking up and down.

Some Experiments with Radiation

We have stated elsewhere that ventilation of all offices, examining rooms and laboratories without vertical ducts in inside partitions was desired. This left only the furred space on the outside wall, which had already been assigned to pipe space and radiators. Why not combine the air inlet with the radiator? How would this affect the heating system? What would be the effect on the ventilation and could the temperatures be more evenly controlled? Suffice to say that we were very hesitant about proceeding, but after some study were convinced that the results which could be obtained warranted the expenditure of money and time for experiments and tests. These resulted in the final design.

The decision to combine the air inlet with the radiator brought up the question of the type of radiation to use. Many styles in each type were presented for our approval. Some of the questions which we had to decide were:

(1) Which would be the most efficient under the two conditions to be met: (a) during the time the building is occupied, when there would be a forced air flow through the radiator; and (b) at night with the ventilation shut down and the circulation would be induced by gravity?

(2) Which type could be most easily housed in air enclosure from which it could be removed or replaced in case of leaks? Which type would give the least trouble from leaks?

(3) Which would be the most easily cleaned?

(4) Which would give the greatest uniformity of heating under the variable steam requirements? Would heat hold-over or quickness in heating up affect the design? Fig. 3 is a photograph illustrating the set-up for a test on copper radiation during experiments. The housing was constructed of an insulating material for ease of construction and remodeling. The fan does not show in the picture, but was installed at the end of the duct shown with dampers for controlling volume and velocity. In the photo will be noted the panel arranged for gravity air circulation. It was desired to maintain 70 deg. inside at night, as there were some doctors and assistants whose work would require their presence in the building. For this reason we installed radiation with a rating sufficient to maintain 70 deg. under gravity circulation. The photograph, Fig. 4, illustrates the accessibility of the pipe shaft and radiator cabinet by removing six screws. To remove the radiator it is necessary to disconnect two unions, unscrew two nipples, remove the slide cabinet panel and slip the unit out. The traps selected for use on the radiation throughout the building are of the multiple diaphragm type with a self-cleaning seat.

Vacuum and Condensate Pumps

Vacuum pumps, in which the air is removed by water displacement, were selected, combined with centrifugal pumps, direct-connected to motors and operated by remote control switches from both float and vacuum switches.

It is not necessary to run the vacuum pumps during the summer, but the condensate from the medium pressure returns must be returned to the central station. The

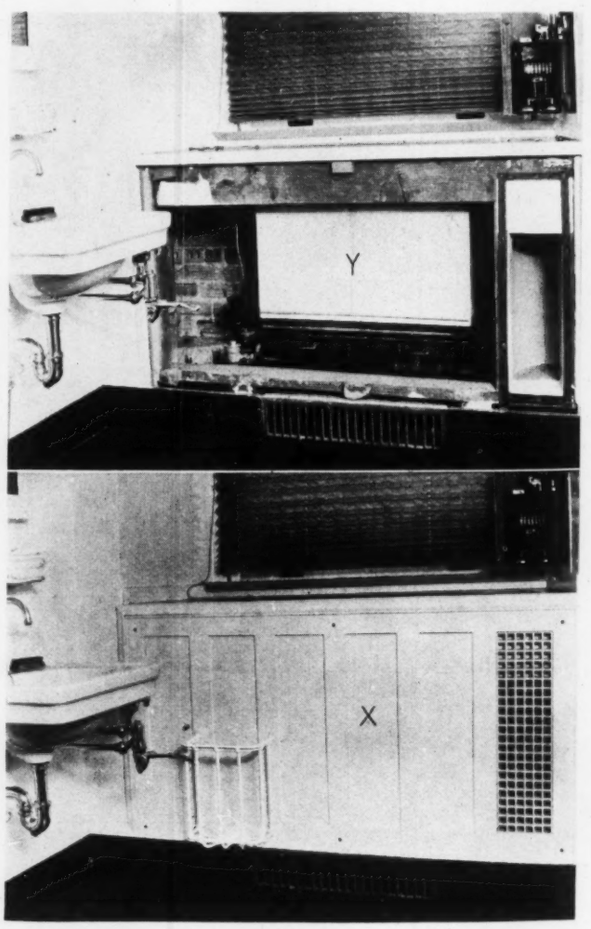


FIG. 4—THE PIPE SHAFT AND RADIATOR CABINET ARE ACCESSIBLE BY REMOVING SIX SCREWS. X—COVER ON. Y—COVER OFF

condensate pumps are controlled by float switches. The vacuum and condensate pumps are duplicated to insure continuity of operation. In order to reverse the operation of the pumps from high to medium float control, or from one vacuum switch to another, a special panel was designed. The principle of our design is copied from the telephone switchboard jack and consists of a series of polarized sockets, each connected to the starting switches controlling the motors. The leads from the float and vacuum switches extend into the cords which may be plugged into any one of the sockets of the same polarity.

From our experience we know that the condensate from the heating system of a large building or group of buildings will return in surges. Desiring to return all condensate to the plant in a steady flow, our pumps are designed to handle the average condensation rate at maximum temperature. The tanks are large enough to handle the surges and give twenty to thirty minutes' operation of the pump between high and low float levels.

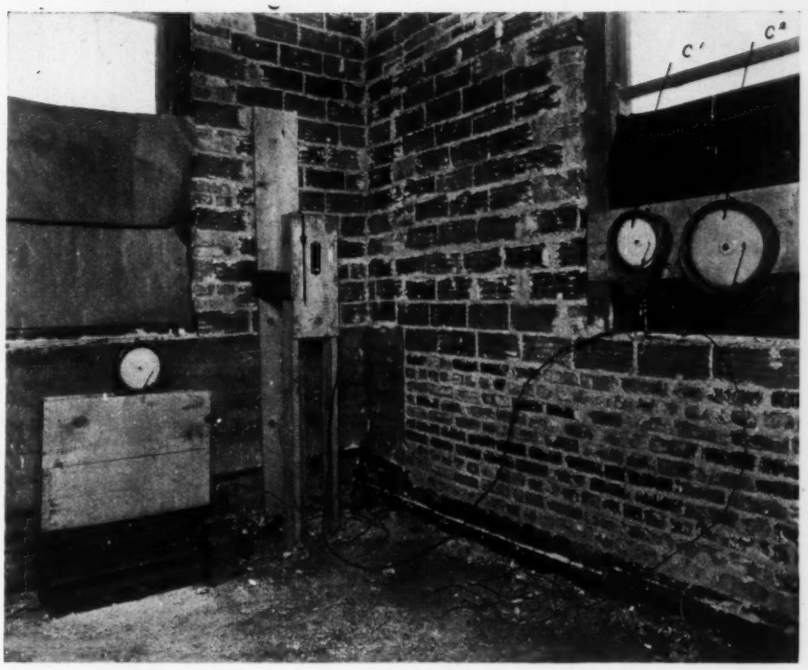


FIG. 5—SET-UP FOR TEMPERATURE-CONTROL TEST. STEAM AND AIR WERE FURNISHED FROM THE FLOOR BELOW

Welding Used in Connecting the Pipe

The kind of pipe to use depends on local conditions and the operation of the heating plant. Steel pipe was used for both heating supply and return mains. For the returns of the medium pressure condensate, brass pipe was installed. All pipe 1½-in. and above was acetylene welded.

Temperature Control

Temperature control often has been a subject of much discussion. Its value is recognized among engineers. Its cost in financial outlay and maintenance is repaid to the owner through heat saving. The added comfort and increased health of the occupants, and the reduced rate of depreciation of materials, frequently is not given sufficient consideration. These values alone are worth the investment. In our combined system the air entering the room is held at a constant temperature to maintain an even room temperature and to prevent drafts. To accomplish this the thermostat must be very sensitive. Many tests were conducted with temporary equipment set up to duplicate actual conditions. We were assisted by several manufacturers lending their equipment and co-operating in carrying on the work. In two instances, manufacturers ran several-day tests under the supervision of the designing engineers. There is a very little difference in temperature between floor and ceiling with this installation. With 70 deg. at the breathing line, the floor temperature is held close to 68 deg., with 72 deg. at ceiling. We believe that this small temperature difference is brought about by the induced recirculation of room air through the radiators.

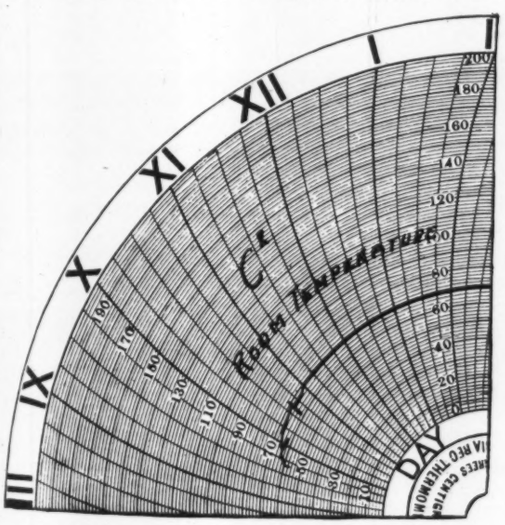
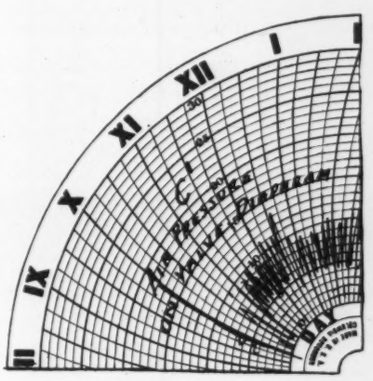


FIG. 6—ROOM TEMPERATURE CHART FOR TEMPERATURE CONTROL TEST

FIG. 7—CHART SHOWING THAT THE AIR PRESSURE IN THE LINE BETWEEN THE THERMOSTAT AND THE VALVE DIAPHRAGM WAS GRADUATED, THUS GRADUATING THE STEAM SUPPLY. THAT IS, THE STEAM WAS NOT TURNED ON AND OFF BUT VARIED IN PROPORTION TO THE REQUIREMENTS



Refrigerants

By Lewis Lipman

DURING the past few years the scope of refrigeration has been greatly widened, taking in nearly every branch of industry and every living condition in some form. This has naturally resulted in a broadening conception among those interested in the application of the various refrigerants to the differing conditions to be met.

For instance, it is evident that the refrigerant used in the production of sub-zero temperatures in certain cold storage rooms might differ from that used to produce a temperature of 70 deg. fahr. desired in cooling office, hotel and theatre buildings. Again, the temperature of 40 deg. fahr. in the household refrigerator might call for a different refrigerant from that used in the storage of ice cream, which is held around zero.

It is felt, therefore, that a brief study of the characteristics of the better-known refrigerants might be of interest at this time.

Requirements for an Ideal Refrigerant

As is the case with every subject and object, there is an "ideal" devoutly to be desired, but as yet undiscovered. The points embracing this "ideal" are aptly set forth by H. B. Hull in his work, "Household Refrigeration." Mr. Hull, in his treatise, states that "the most desirable refrigerating media possess the following properties:

1. A high latent heat as well as a high ratio of the latent heat to the specific heat of the liquid, in order to produce a large refrigerating effect per cycle of operation.
2. A boiling point at ordinary atmospheric pressure low enough to obtain the temperature desired.
3. A condensing temperature (or boiling point) at a relatively low pressure.
4. A low specific volume of vapor.
5. A high critical temperature.
6. A low ratio of compression.
7. A non-corrosive action on metals.
8. A chemical composition which is stable under working conditions and inert on lubricants.
9. A non-inflammable and non-explosive nature even when mixed with air.
10. An inoffensive odor, non-injurious to health.
11. A behavior whereby its presence in small quantities may be visibly detected by a simple test.
12. A low cost of production for a product of necessary chemical purity for commercial use.
13. No affinity for constituents of the atmosphere whereby leaks might form gases or acids affecting the normal operation of the system.
14. A non-corrosive action on desirable bearing materials."

No Ideal Refrigerant

Now, the foregoing list of fourteen points covers what would be the ideal refrigerant. Since this ideal refrigerant has not yet been revealed, it is necessary for us to take the qualities and characteristics of the better-known refrigerants and from these determine the refrigerant to be used for any particular application.

Needless to say, the various manufacturers of refrigerating machinery, from the largest commercial unit to the smallest household unit, have given what each believes to be the necessary and proper research into this matter of refrigerants before determining upon his particular choice. In making such a choice, they have taken into consideration that some of the points were of greater importance than others. It must be borne in mind, however, that characteristics of minor importance in one type or size of equipment might be of major importance in another.

The various properties of several refrigerants are shown in the accompanying table.

CHARACTERISTICS OF REFRIGERANTS

	Sulphur Dioxide	Ammonia	Methyl Chloride	Carbon Dioxide	Ethyl Chloride	Butane	Propane	Ethane
Chemical Symbol	SO_2	NH_3	CH_3Cl	CO_2	C_2H_5Cl	C_4H_{10}	C_3H_8	C_2H_6
Molecular Weight	64.06	17.032	50.47	44.00	64.50	58.10	44.09	30.06
Critical Temperature, Degrees F	311.0	271.4	289.0	88.2	360.5	311.0	216.0	90.0
Critical Pressure (Lbs. Abs.)	1160.0	1650.0	1029.0	1073.0	784.0	544.0	647.0	720.0
Boiling Point, Degrees F	+ 14.0	− 28.03	− 10.65	−110.5	54.5	31.0	− 49.0	−135.0
Melting Point, Degrees F	−104.0	−107.9	−154.0	− 70.8 (sublimes)	−214.5	−211.0	−317.0	−276.0
Density of Liquid at 32 Degrees F. (Water = 1)	1.44	0.6386	0.952	1.56 at 68° F.	0.920	0.60	0.536	0.446
Density of Gas at Atmos. Pressure and 32 Deg. F. (Air = 1)	2.2634	0.596	1.782	1.5289	3.06	2.006	1.5620	1.0489
Pounds per cu. ft. at Atmos. Pressure and 32 Degrees F	0.1827	0.0517	0.1438	0.12341	0.2276	0.1619	0.12608	0.08467
Ratio of Specific Heats of Gas	1.3977	1.3	1.20	1.2995	1.15	1.108	1.142	1.201
Specific Heat at Constant Pressure	0.1544	0.52	0.24	0.2012	0.274	0.351	0.365	0.397
Specific Heat of Liquid at 32 Degrees F	0.41	1.099	0.465	0.79	0.427	.....	.....	.....

Compiled from data by H. D. Edwards and U. S. Bureau of Standards.

Steam Traps

By T. H. Rea

A STEAM trap is an automatic valve for removing condensate from a steam line or steam heated unit without the loss of live steam. This definition applies to the separating type of trap that requires a pressure drop between the inlet and outlet lines for successful operation. The direct return or pumping trap, on the other hand, is filled with condensate at one pressure and discharges this condensate to a boiler which is under greater pressure than the return lines from which the condensate is removed. This paper, and four subsequent articles, will be confined to separating traps.

If a man from Mars were to talk to some engineers he might get the idea that a steam trap was designed to catch and retain air, fill up with dirt and grease, and to develop leaky valves in the shortest possible time. This would not be fair to steam traps in general and the same Martian in talking to a few individuals might gain the impression that the automobile was a clever contraption to keep young people from home and old people in the hospitals. The steam trap is guilty as charged, likewise is the automobile; but this is not the whole truth. Most automobiles have moral and homicide records that are 100 per cent clear and thousands of steam traps have been on the job for years passing condensate, air and dirt without any attention whatever.

Two Classes of Trouble

Steam trap troubles can be classified under two heads, first (and the easiest to locate and remedy) bona fide trap troubles that are usually mechanical, such as leaky valves, water-logged floats, worn pivots, and so on without end; second, imaginary trap troubles. Under this heading should be included system troubles for which the trap is blamed such as pressure being too high, broken siphon pipe, or incorrect installation of the trap. These are real troubles but they are not trap troubles. Then there are the imaginary troubles which traps are accused of making, when in reality both the steam system and the trap are operating to perfection. Many a steam trap salesman has had the experience of traveling many miles to service leaky traps only to find that the operator has mistaken flash steam for live steam in the trap discharge. If murder is ever committed under these circumstances, a jury of trap salesmen would vote the prisoner a distinguished service medal. Traps have also been accused of keeping steam-heated apparatus too hot while all the trap does is to keep water and air out of the steam chamber and steam pressure governs the temperature. In fact, steam traps have been the goat when anything goes wrong with a steam system.

Leaky Steam Trap Expensive

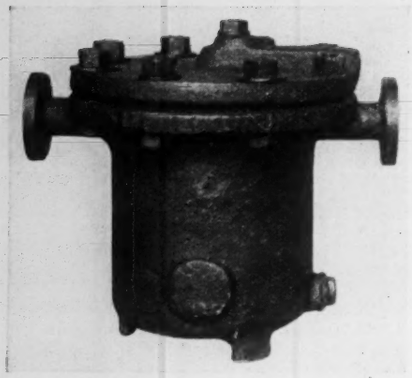
A balky steam trap will cause no end of trouble in a steam plant. Water in the steam supply line will not only cause water hammer but might even wreck an engine or turbine. Even if no damage is done, condensate cuts down the steam volume and heat transfer surface thus lowering efficiencies. On the other hand, while a leaky trap will keep a line drained, it will also waste a lot of steam. Assuming a steam cost of 60 cents per thousand pounds at 100-lb. pressure, a ⅛-in. diameter leak will cost $30.30 per month. Hence steam traps must be kept in first class mechanical condition with steam-tight valves in order to insure safe and economical operation of steam lines or steam-heated machines.

Traps Require Inspection

Unless the proper size and type of trap is selected for a particular job, it is impossible to obtain satisfactory or economical trap operation. Even after the right trap is installed, trouble is likely to occur if the engineer overlooks the fact that a trap is an automatic machine and, like any other machine, requires periodic inspection to make sure it is working as it should and in first class mechanical condition. "A stitch in time saves nine" applies to steam traps as well as to trouser seams. A slight valve leak can be lapped out or at the most new valve parts can be purchased for a nominal sum. If the leak is not attended to, not only are the valve parts ruined but the entire trap mechanism may need replacement on account of the excessive wear that takes place when a trap blows steam.

There are many points concerning steam traps on which information has been confusing or wholly lacking. In this series on the subject, of which this is the first article, the author will clear up these points rather than present a complete treatise on traps.

Subsequent articles of the series will be concerned with factors affecting trap capacity, trap installations for process work, installation and operation of traps, and trap troubles.



TWO STEAM TRAPS SHOWING MODERN REFINEMENTS IN CONSTRUCTION AND DESIGN. THE OLD STYLE TRAP ON THE LEFT WEIGHS 116 LBS. WHILE THE MODERN TRAP OF THE SAME CAPACITY CONTAINS 18 LBS. OF MATERIAL

There is nothing mysterious about steam trap operation or about steam trap troubles. There are troubles peculiar to each type or make of trap and there are general troubles that can easily be avoided. The purpose of these articles is as follows:

First: To point out factors controlling trap capacity.

Second: To point out factors governing the size of trap that should be selected for any particular job.

Third: To point out fundamental rules governing the installation of traps.

Fourth: To describe common trap and system troubles and to point out ways and means for overcoming these troubles.

Laws Influencing Trap Design

Before going ahead with the above program, it is well to review the fundamental steam laws that govern steam trap operation and influence steam trap design.

By definition a British thermal unit (B. t. u.) is the amount of heat which will raise the temperature of one pound of water one degree fahr. The application of 180 B. t. u.'s to a pound of water at 32 deg. fahr. would raise the temperature of this water to 212 deg. fahr. or to the boiling point. If this pound of water is in an open vessel, additional B. t. u.'s will not raise the temperature of the water but will change the water into steam. Some 970.4 B. t. u.'s will be required to complete the evaporation of one pound of water at atmospheric pressure.

If, however, the water is in a closed vessel and suitable means are employed to maintain a definite pressure, say, of 10.3 lb. gage, 208.4 B. t. u.'s would have to be applied to the pound of water at 32 deg. fahr. before the boiling point is reached. The temperature of the boiling point at 10.3 lb. gage pressure is 240.1 deg. fahr. Although at this pressure, additional B. t. u.'s are necessary to bring the water to the boiling point, fewer B. t. u.'s are required to change the water into steam, only 952 being necessary instead of 970.4 at atmospheric or zero gage pressure. As the pressure rises, more heat is required to bring a given amount of water to the boiling point but less heat is required to evaporate the water. Steam tables are available that give steam temperatures, heat required to evaporate a pound of water, heat required to raise water to the boiling point, and the total heat of steam for pressures ranging between almost a perfect vacuum and 3,300 lb. per sq. in. The accompanying condensed steam table will be referred to in this and subsequent articles on steam traps.

It will be noted that both gage and absolute pressures are given in the above table. Gage pressure is the pressure in pounds above atmospheric pressure at sea level, which is 14.7 pounds per square inch. Absolute pressure is pounds per square inch above an absolute vacuum.

Steam tables are used in designing steam engines, turbines, and heat transfer apparatus. In the plant a steam table can be used to determine temperature when pressure is known or check pressure gages when temperatures are known.

The heat required to evaporate water is known, of course, as latent or hidden heat in that no temperature rise takes place as additional heat units are applied to the boiling water. A pound of water at 212 deg. fahr. is no hotter according to the thermometer than a pound of steam at 212 deg. fahr., although the pound of steam has 970.4 B. t. u.'s more than the pound of water. In fact a pound of steam at 212 deg. fahr. can be added to 5.39 pounds of water at 32 deg. fahr. to give 6.39 pounds of water at 212 deg. fahr. Still, a pound of water is just as "hot" as a pound of steam. This is an excellent illustration of the difference between heat and temperature.

As steam gives up its heat to the pipe or apparatus in which it is contained, it changes to water. With steam at zero gage pressure for every 970.4 B. t. u.'s given up, a pound of water or condensate is formed.

STEAM TABLE

Inches Mercury	Absolute Pressure	Fahrenheit Temperature	Latent Heat	Heat of Liquid	Total Heat of Steam
27.8	1	101.8	1034.0	69.8	1104.
19.7	5	162.3	1000.3	130.1	1130.5
9.5	10	193.2	982.0	161.1	1143.1
0.0	14.7	212.	970.4	180.	1150.4
Gage Pressure					
.3	15	213.	967.7	181.	1150.7
10.3	25	240.1	952.	208.4	1160.4
20.3	35	259.3	938.9	227.9	1166.8
30.3	45	274.5	928.2	243.4	1171.6
40.3	55	287.1	919.	256.3	1175.3
50.3	65	298.0	911.	267.5	1178.5
60.3	75	307.6	903.7	277.4	1181.1
70.3	85	316.3	897.1	286.3	1183.4
80.3	95	324.1	890.9	294.5	1185.4
90.3	105	331.4	885.2	302.0	1187.2
100.3	115	338.1	879.8	309.0	1188.8
185.3	200	381.9	843.2	354.9	1198.1
285.3	300	417.5	811.3	392.7	1204.1
385.3	400	444.8	786.0	422.0	1208.
485.3	500	467.3	762.	448.	1210.
985.3	1000	544.9	651.	535.	1186.
1485.3	1500	594.	567.	596.	1163.
1985.3	2000	631.	476.	657.	1133.
3285.3	3300	705.	0.	914.	914.

At higher pressures, fewer B. t. u.'s are required to produce a pound of condensate. This giving up of heat to form condensate is at once a blessing and a curse; in this respect steam is similar to friction. Steam giving up its heat, or condensing in transmission lines, not only wastes heat but the condensate is a potential source of trouble. Steam giving up its heat in heating coils, kettles, engines and turbines performs useful work or service and has helped make possible our present state of industrial and chemical development.

Removal of Condensate Essential

Regardless of whether the condensation of steam results in a heat loss or does useful work, the condensate formed must be removed. Condensate forming in steam lines may seriously damage, if not totally wreck, engines and turbines, while water hammer may seriously affect piping and equipment. Condensate remaining in heating coils and the like will not only cut down the volume of steam and heat transfer efficiency but also damage the coil or steam-heated machine.

The Cracked Valve

The simplest method for removing condensate from steam lines is to install valves at suitable points and open these valves just enough to allow the condensate to escape without the loss of any live steam. Simplicity is the only recommendation for this method. In the first place it is next to impossible to crack a valve so all condensate will be eliminated and let no live steam escape. Where possible to adjust a valve with such nicety, the inevitable variation in the amount of condensate would bring about a condition whereby either the condensate would back up in the steam lines or live steam would escape. In addition to the cost of live steam wasted and the loss of efficiency or damage of equipment due to faulty elimination of condensate, the cracked-valve method is expensive on account of the steam cutting out the valves. Another consideration is the failure of this method to provide for emergency conditions. A slug of water could not be handled quickly.

Steam Trap an Automatic Valve

In order to overcome the inherent weakness of handling condensate by means of cracked valves, automatic valves called steam traps have been devised. The primary function of a steam trap is to remove condensate without loss of any live steam. Traps are usually selected with sufficient excess capacity to handle all the condensate that might have to be taken care of under the most severe operating conditions.

If a steam trap were never called upon to handle anything but 100 per cent pure water and if steam could be generated free from air or incondensable gases, steam trap design would be greatly simplified. However, since it is out of the question to insure these perfect working conditions, trap design must take the bad air and water conditions into consideration. Let us briefly review some of the factors that affect steam trap operation and design.

Air Binding

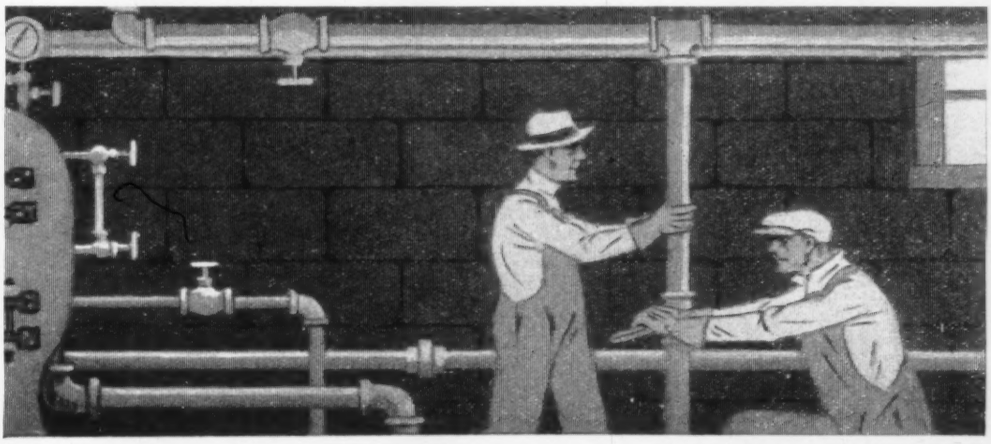
Air is practically always present with steam. This is due both to the air present when the steam is turned on and to air that is introduced in the boiler along with the feed water. Even though the actual percentage of air in steam is very low, as steam is condensed the percentage of air increases and a steam trap that will not handle air automatically and without loss of live steam is almost certain to cause trouble. This point cannot be stressed too strongly. Air binding is probably responsible for more trap operating trouble than any other single cause.

It hardly seems necessary to point out why it is desirable to have a trap remove air as it comes to the trap. In the first place, if the air is not removed, condensate cannot get to the trap and hence the trap ceases to work. Not only does the condensate back up into the system, but the air mixed with the steam also cuts down the heat transfer capacity of the system.

Oil and Grease Cause Trouble

Sediment, sludge and scale are frequently found in steam lines. Unless a trap will rid itself of this material, it will soon fill up and quit on the job.

Oil and grease, so frequently encountered in exhaust steam lines, is another source of trap trouble. Unless these impurities are removed, they are certain to keep the trap from working. Heavy grease and oil are especially difficult and even though the trap will handle grease while hot, unless the trap body is



kept free from grease it will harden when cold and put the trap out of action.

Cutting Action of Water

A mixture of steam and water under pressure will escape through a restricted orifice at a very high velocity. The fine water particles at this velocity have a cutting action similar to a sand blast and ordinary metals will not stand up long under this severe service. The smaller the orifice without reducing the velocity of the steam, the greater the cutting effect. There are two reasons for this; first, with a given quantity of water to be discharged, the smaller the orifice the greater is the proportion of water that will come in actual contact with the metal in the orifice. Second, with a given quantity of water to be discharged, the smaller the orifice, the longer is its time of discharge, assuming operating pressures are equal. It is apparent then, that the greatest cutting effect or wire drawing will take place just as the valve is being pulled away from its seat or just as the valve is seating. Steam trap manufacturers have attacked the wire drawing problem in three ways: first, quick opening and quick closing of the discharge valve reducing wire drawing to a minimum; second, water sealing the valve so that only water is discharged, and third, the use of high grade materials for valve stems and seats, some of which require heat treatment.

Economic Factors

The above paragraphs cover some of the difficulties of steam trap operation that affect design. No less important are the economic factors of size and cost. Modern engineering practice calls for traps on individual heating and process units, and manufacturers have met this trend by designing traps, the cost of which will not offset the economic and operating advantages of individual trapping. Proper size of traps, as in other mechanical equipment, means low cost because of savings in operating and replacement expense.

It is evident then, that steam trap design must take a wide range of physical and economic factors into consideration to satisfy operating conditions.

Editor's Note: The second of Mr. Rea's series on traps will appear in an early issue of this publication.

Protecting Storage Tanks

Storage tanks containing inflammable liquids are subject to destruction by lightning. The effluent gases escaping from the manholes and vents of a tank may easily become ignited by lightning. To prevent destruction of the tank and its contents, the principle employed in the construction of the Davy safety lamp is used. Brass gauze is fitted in the mouth of each vent on the tank. During an electrical storm the issuing gases are frequently ignited but the flame dies out when no more gas issues from the vent. The flame does not pass through the gauze because the metal conducts the heat away so rapidly that the temperature of the gases inside the vent does not reach the flash point. A periodical and rigid inspection of the gauze prevents serious losses.

Cork Insulation of Cold Storage Warehouses

By Clarence E. Baker

ONE of the greatest single factors in the construction of an efficient cold storage warehouse is that of providing the most suitable insulation. A building that is properly insulated can be cooled by a refrigerating plant of smaller capacity and with a much smaller expenditure of power than can an improperly insulated building. This simple fact alone may determine the success or failure of a refrigerating assembly. Even when efficient insulation is provided a certain factor of heat loss must be taken into consideration, as no insulating material is 100 per cent efficient.

Many makers of refrigerating equipment reserve the right to draw up specifications covering the insulation of jobs using their machines; other companies specify a plant of a size to suit the existing or specified insulation, and still other companies permit the installation of their equipment without regard for the insulation to be used. In the latter case, the buyer assumes all of the responsibility.

Too frequently, contractors are prone to cut on the insulation item when figures are running high. This, of course, is a serious mistake and one that means a constant expenditure of power throughout the lifetime of the plant in making up for a deficiency in insulation.

"Insulation against heat," as cold storage insulation sometimes is designated, involves the same principles as insulation against cold. It is simply a matter of heat transfer or thermal conductivity, the only difference concerned being in the direction of the flow of heat. "Cold" itself is a relative term, meaning only a partial absence of heat. In insulating a cold storage room, therefore, the principle involved is that of preventing outside heat from entering the room through the walls, floor or ceiling. The heat contained in the stored produce is absorbed in the refrigerant and removed with it until the required temperature is reached. The degree of efficiency with which this is accomplished depends upon the amount of heat that finds its way into the storage compartment through air leaks about doors, or that is permitted to enter the room through improperly insulated walls and floors. Heat gaining entrance in this manner must also be removed to maintain the required temperature of the stored produce, hence an increased duty is imposed upon the mechanical equipment.

Heat Entrance Through Building the Largest Factor

Competent authorities estimate that in the average cold storage plant three-fourths of the work of the refrigerating machine is necessary to remove the heat that finds its way into the storage rooms through supposedly insulated surfaces; only one-fourth of the work of the machine is necessary to refrigerate the goods in storage. It is impossible to check entirely the entrance of heat with the most efficient insulating materials but the loss from this factor may be reduced to a small amount.

Throughout the history of cold storage construction many insulating materials have been used with varying degrees of success. Cork is used widely for cold storage work. Many storage insulation specifications call for 4 in. of corkboard insulation on rooms to be carried in the

neighborhood of 30 to 32 deg. fahr., such as apple or egg storage rooms, while 6 in. or more may be specified on meat rooms or sharp freezers, where temperatures of —20 deg. fahr. or below are required. The following thicknesses of corkboard for different conditions are specified by one of the companies manufacturing this material:

Temperatures	Thickness (Corkboard)
—20° to — 5° F.	8 inches
— 5° to + 5° F.	6 inches
+ 5° to 20° F.	5 inches
20° to 35° F.	4 inches
35° to 45° F.	3 inches
45° and above	2 inches

For bottoms and sides of brine or freezing tanks 5 to 6 in. of corkboard or 12 in. of granulated cork, well tamped in place, are used.

Because of this apparent standardization in the use of corkboard for cold storage insulation, many architects and contractors do not fully realize the qualities necessary in an efficient insulating material, and if called upon to vary their specifications would have a rather hazy idea as to what qualities to look for in a substitute.

Calculating Coefficient of Conductivity

Macintire[1] presents the following formula for calculating the coefficient of conductivity of building materials and insulation, based upon the number of B.t.u. which will pass through the construction under consideration per hour or per 24 hours. This usually is rated for each square foot, 1 inch thick, with a difference in temperature on each side of 1 deg. fahr. Knowing the leakage loss at 1 deg. fahr. the loss at any temperature variation may be calculated:

$$Q = A \times K \times (t_{\text{outside}} - t_{\text{inside}})$$

Where A equals the area of material of the wall in square feet, K equals the conductivity of the material and t equals the temperature in deg. fahr. The value of K may be obtained from Bureau of Standards tables and other authorities.

In built-up walls involving several materials, K may be determined as follows:

$$K = \frac{1}{\frac{T_1}{C_1} + \frac{T_2}{C_2} + \frac{T_3}{C_3} + \text{etc.}}$$

Where T_1, T_2, etc. = the thickness of each material in inches and C_1, C_2, etc. = the conductivity for the materials used as given in standard tables. Typical values for C are given in the following table:

Coefficient of Conductivity of Building Materials
(In B.t.u. per Sq. Ft., per Inch Thickness (Unless Otherwise Specified) per Deg. fahr. Difference of Temperature per Hour).

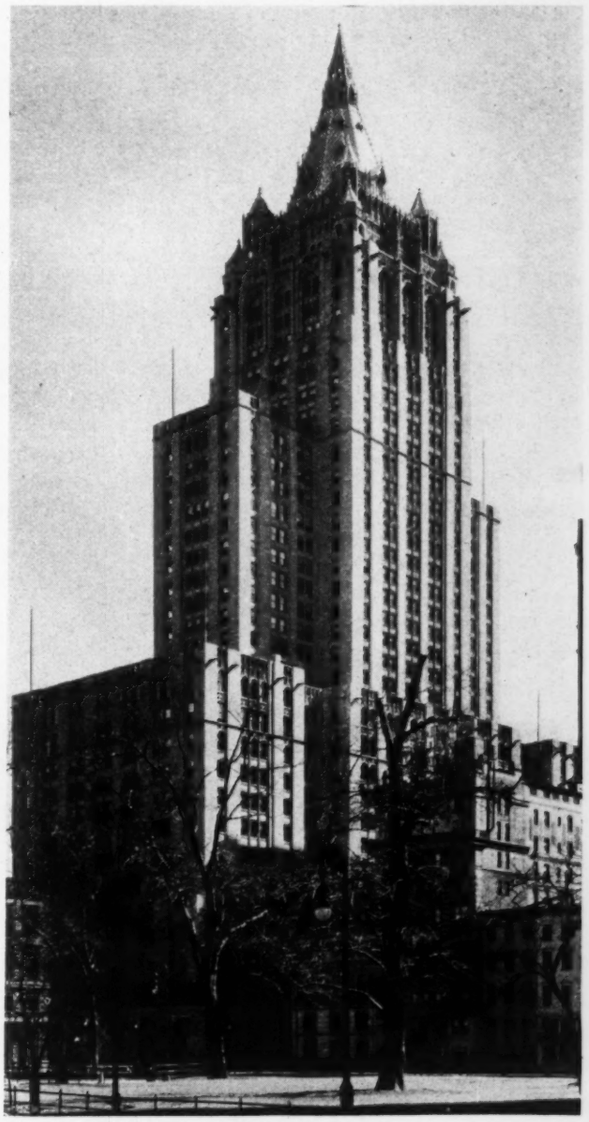
Concrete	5.3 (average)
Brick	5.0
2-in. Hollow tile, plastered	1.0
4-in. Hollow tile, plastered	0.6
Mortar	8.0
Wood (Fir ⅞ in. thick)	1.0
Corkboard (High grade)	0.25

To possess a high insulating value a material must have a low thermal conductivity, the poorest conductor of heat being the best insulating material. Cork has a very low thermal conductivity and frequently is used as the basis of comparison for other materials. The low thermal conductivity of cork is accounted for by the large number of minute, air filled cells or pores that make up the material. There are several grades of corkboard made from cork of different densities; the lower the density the greater the insulating value. The efficiency of cork also varies with the way in which it is manufactured. Some of the best grades of corkboard use no artificial binder. The blocks are made by pressing the cork granules into a mould under high temperature and high mechanical pressure. The natural gums

[1] Macintire, H. J. The Principles of Mechanical Refrigeration. McGraw-Hill Book Company, New York, New York. 1928.

A Million and a Half C. F. M.

In connection with the rapidly increasing use of fans for innumerable purposes, it is interesting to note the large volumes of air that are being handled in modern office buildings. In the New York Life Insurance Building, for instance, there is a total capacity of 1,447,845 cubic feet per minute supplied by 56 fans or a total of 486 hp. for the ventilation of 21,505,000 cubic feet of space..

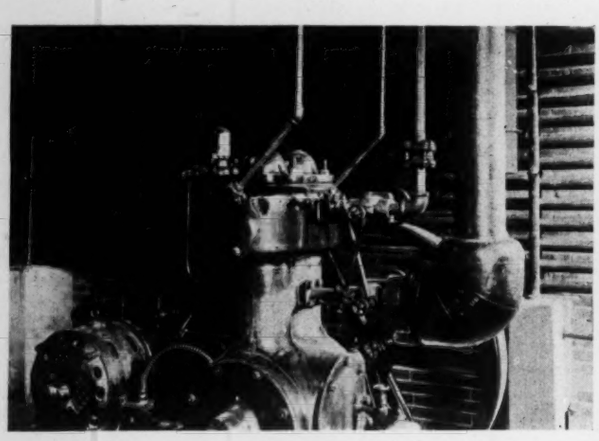


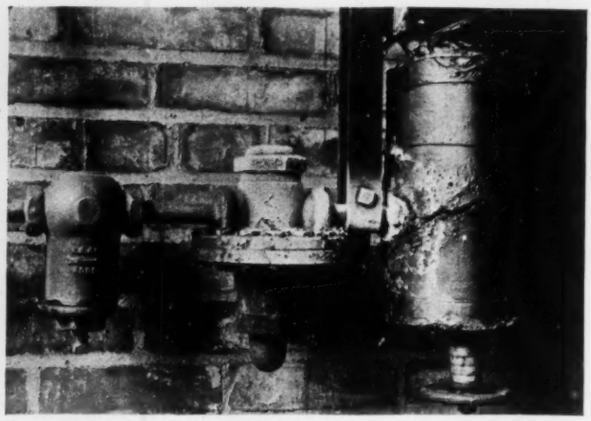
New York Life Insurance Bldg.

of the cork, melted by the high temperature, serve as cementing materials holding the granules firmly in place. Such blocks are carefully tested for uniformity of strength and structure and are weighed to determine their density. The lightest blocks may be lacking in structural strength while the heavy blocks are known to be lacking in insulating qualities. Other grades of corkboard may use an asphaltic binder for holding the granules in place. Such binders sometimes raise the thermal conductivity of the corkboard, thereby reducing its insulating efficiency.

It is usually customary to apply cork in several layers rather than to employ a single layer of the desired thickness. In laying up a 4-in. corkboard insulation a 2-in. layer usually is fastened to the masonry by coating the wall with hot asphalt and by dipping the back and ends of each block before setting in place. This holds the cork firmly against the wall and protects against the entrance of moisture or water vapor from the masonry wall. The second 2-in. layer is placed over the first one in such a manner that both the horizontal and vertical joints are broken, thus closing any opening that might extend through one thickness of the insulation at an imperfectly fitted joint. This is a very important consideration as leaks of this nature are dangerous, not only through heat losses but through a failure of insulation due to ice formation from condensed moisture that may get into the insulating material. This fact also indicates the importance of an airproof and waterproof outer covering. A ½-in. coating of cement plaster should protect the cork on all walls and ceiling. Floor insulation generally is well protected, providing the concrete is waterproof and well laid.

Wall insulation in storage warehouses sometimes fails following an injury to the cement plaster covering where it is possible for moisture to reach the material. More frequent is the failure from the entrance of warm air through imperfections in the masonry wall, permitting the moisture laden warm air to come in contact with the cold insulation. When this happens the water vapor is condensed and deposited upon the insulation where it freezes and expands sometimes loosening the insulation.





RIGHT—THE BEGINNING OF AN INSULATION FAILURE IN THE CORK COVERING OF AN EXPANSION LINE. THIS FAILURE IS CAUSED BY THE ENTRANCE OF WARM AIR BENEATH THE INSULATION AND THE RESULTING ICE FORMATION WHICH IS FORCING THE INSULATION AWAY FROM THE PIPE

LEFT—A WELL-INSULATED SUCTION LINE ON A SMALL COMPRESSOR. MOULDED CORK PIPE COVERING IS PROTECTED BY SEVERAL COATS OF AN ASPHALT PREPARATION TO EXCLUDE ALL POSSIBILITY OF AIR ENTERING THE INSULATING LAYER

"Open for Discussion"

A department in which we follow the custom of technical societies of allotting space in their programs for discussion of the papers presented

UNIT HEATERS

"Making the Unit Heater Fit the Job," *by C. D. Graham.* Page 377, issue of September, 1929

I HAVE read with great interest and attention the paper by Mr. C. D. Graham, published in your September number, "Making the Unit Heater Fit the Job."

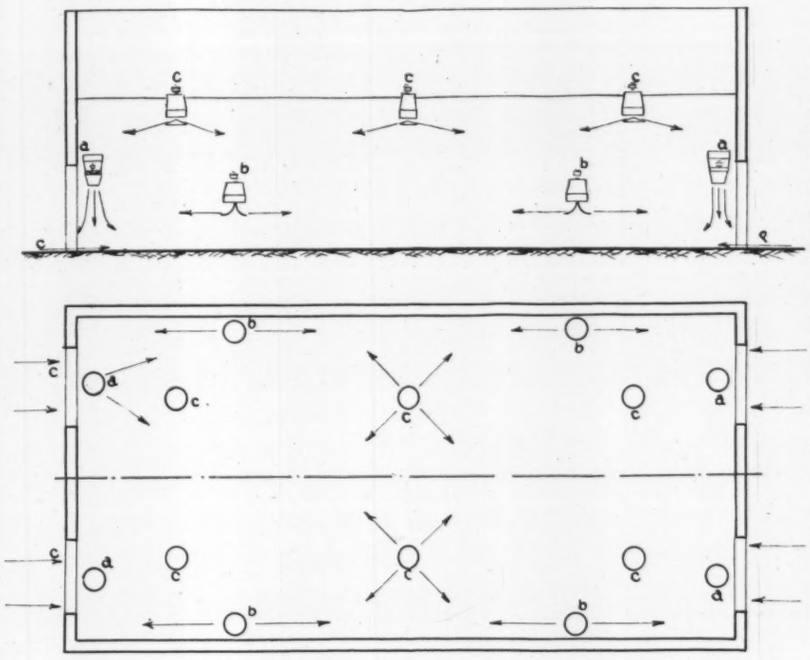
In France, we use suspended units which take the air on the top, bring it to a higher temperature and send it down with as high a speed as possible, this speed being limited by the necessity not to produce disagreeable drafts.

But in most French installations the desired temperature is only 54 to 59 deg. fahr. which is only four to nine degrees above the ground temperature, and the heat loss per unit of ground surface is generally low. Consequently a very small quantity of heat is necessary to counterbalance this loss.

The low temperature of the air near the ground is for the most part produced by outside air entering through the lower interstices; particularly door interstices. This air being heavier remains near the ground. To prevent the inconvenience we use two methods:

1. If the upper part of the building is air-tight, the neutral zone being near the floor, heat is brought to the floor by blowing hot air taken from outside and passing through one or several unit heaters. The building is entirely under pressure and no cold air is allowed to get in.

2. If the upper part is not air-tight, it would not be possible to bring the neutral zone to the ground without a great increase in air heated and consequently an increase in the coal bill.



HEATERS A AND B SUPPLY LOSS THROUGH WALLS AND COLD AIR INFILTRATION. HEATERS C SUPPLY HEAT LOSSES THROUGH THE ROOF

When this is the case, we place unit heaters near or above the doors, and the hot air is projected directly to the ground without any deflector. The hot air is poured out near the ground, mixing with cold air entering through lower interstices. People passing through the door feel a vertical draft of hot air, but are not incommoded, as they would be if they had to stand in the draft.

In such workshops, unit heaters are placed near the doors and outside walls giving the heat necessary to withstand the cooling effect of outside walls and of the whole air change; other unit heaters have only to withstand the cooling effect of the roof. The air movements are indicated in the sketch.

—A. Beaurrienne.

HEATING RAILWAY PASSENGER CARS

"Practical Piping Problems," *by W. H. Wilson.* Page 264, issue of July, 1929

I HAVE read with interest your article on "Heating Passenger Cars" which appeared in the July, 1929, issue of HEATING, PIPING AND AIR CONDITIONING. We are at present making an analysis of operating costs of an isolated power plant supplying steam and electricity to a large railroad terminal and yards. It is extremely difficult to obtain any measurements of the steam supplied for heating passenger cars in the yards from the yard steam line and we would greatly appreciate any general information you may have as to passenger car steam consumption under various conditions.

R. V. Armistead,
Industrial Engineer.

The Author Answers

The amount of steam required for heating railway passenger cars, used on steam roads, while cars are standing in the yards at the terminals, naturally varies under the different weather conditions, the type of cars, whether it be a day coach, sleeper, diner or other type of car and the heating system.

The following is a result of tests made for cars that have the heating installed in the form of sections or circuits, such as sleepers, club and compartment cars, 110 pounds of steam being carried on the train line. Vapor system of heating being used and the outside temperature 20 deg. fahr.

One—circuit of piping being in use—55 pounds per hour.

Two—circuits of piping being in use—110 pounds per hour.

Three—circuits of piping being in use—165 pounds per hour.

Four—circuits of piping being in use—220 pounds per hour.

This is an average of several tests.

On account of the steam traps used on cars, discharging to the atmosphere, some of the steam passes away in the form of vapor and this could not be readily computed. Amount of steam used was determined by collecting the water from the condensed steam from the steam traps of the car heating system and weighing it. In connection with this matter, some steam is lost through the end valves, as it is common practice when the steam supply is attached to one end of a car, or several cars coupled to open the end valve on the opposite end slightly (termed cracking the valve) and permit some steam to escape to keep the end valve and a portion of the train line from freezing. In order to insure safety from danger from freezing the end valve is frequently opened more than is economical practice. In order to estimate the steam lost in this manner it is suggested that for estimating purposes the steam lost in this manner be estimated or the amount of steam passing through a 1/32-in. orifice which according to standard authorities would be about 20 pounds of steam per hour at 110 pounds pressure, which should be added to the figure previously mentioned for each end valve that is set to allow steam to escape.

It has been observed that in many cases, where cars are temporarily connected to the yard steam line, that the yard connections are not assembled carefully and steam losses of some extent can be attributed to that cause.

—W. H. Wilson.

Drying by Vacuum

By Charles Byrne

THEORY and practice in vacuum drying are based upon fundamentals of engineering familiar to all. At least we obtain these fundamentals in college in various courses in physics and engineering. The basis for vacuum drying lies in the increased capacity which can be secured by enlarging the temperature difference between the heat supplied and the liquid which must be removed. The capacity is actually increased by accelerating the evaporation; thus we have the effect of vapor pressure lowering on the boiling temperature and the effect of the three forms of heat, especially radiant, on materials and liquids.

Strange as it may seem, very little information on this subject of vacuum drying is to be found in technical literature. As in the ancient mysteries, only a chosen few appear to have been initiated. There is reason to believe that part of this lack of information is due to the differences between the English and the metric systems of weights and measures. Then too, if the thought of vacuum had never been applied, much misunderstanding would have been avoided, as only the absolute scale of pressures would have been used.

For the purposes of this paper, then, the discussion will be carried on in terms of absolute pressure expressed as pounds per square inch as well as millimeters of mercury. Those who have always thought in terms of vacuum have only to remember that 29.92-in. Hg, in vacuum, is equal to zero pressure on the absolute scale while zero vacuum is equal to 14.696 lb. per sq. in., or 760 mm. Hg on the absolute scale.

Equipment Used in Vacuum Drying

Vacuum drying involves the use of metal containers designed to resist the pressure of the atmosphere on the outside, of vacuum pumps, of condensers in which the hot vapors can be converted into liquids and of receivers where the liquids can be caught. In addition there is, usually, a control system so that temperatures and pressures can be held at the desired point. The schematic arrangement is shown in Fig. 1 for what is known as a single effect drier. In the drying of chemicals it is often desirable to have more than one vacuum drier in a series arrangement to secure economy in the use of steam and vacuum. Such arrangements are known as multiple driers. In the scheme shown in Fig. 1 the motive power for the pump may be an electric motor, as shown, a reciprocating engine or a turbine. The vacuum pump, in its turn, may be of the reciprocating, rotary or jet types.

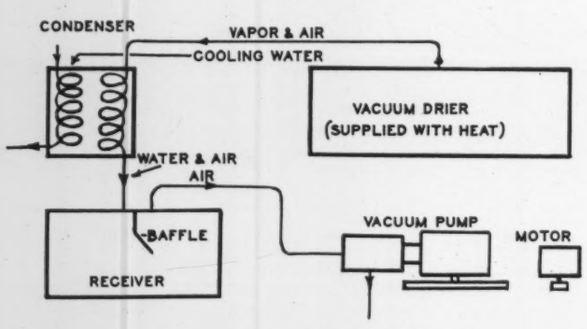


FIG. 1—LAYOUT FOR VACUUM DRYING

Obviously vacuum drying costs more, for equipment and installation, than atmospheric systems of the more simple form where fans and heaters alone are used. From a production standpoint it can compete favorably with atmospheric air conditioning systems where air washers and coolers are used providing, of course, that the product can be dried either way. It is probable that low humidity air conditioning at atmospheric pressures would give production costs lower than vacuum drying, now that refrigeration can be supplemented or supplanted by chemical processes of dehydration, since relative humidities lower than ½ per cent have proved practical, it being possible to obtain dewpoints down to —40 deg. fahr. This latter process would make it possible to use large rooms, to enter and leave such rooms at will, and to seal the product against regain of moisture before it is removed from the dry atmosphere. When this system comes into general use vacuum drying will still have a field to serve which air conditioning, apparently, can not touch.

The effect of lowering the vapor pressure, by means of a vacuum, on the boiling point is illustrated in Fig. 2 where curves for three liquids are shown. These liquids are water, carbon tetrachloride and amyl alcohol. The main reason for showing the effect on the last two liquids is simply to make clear the consistency with which a reduction in vapor pressure lowers the boiling point. As moisture in the form of water is the usual liquid evaporated and removed it will be interesting to observe its curve. It then becomes evident that the best results can be had at pressures very close to the absolute zero. The closeness with which one works to this zero depends on costs and the quality desired in the product.

The maximum temperature which can be employed, without deterioration of the substance or material to be dried, is raised by vacuum drying because, under these conditions, the natural color of the product is not destroyed and the hygroscopic or residual moisture in the material is not lost at temperatures which would prove fatal under atmospheric pressure. This fact has resulted in the use of vacuum methods of drying for colored paper products, textiles, glue, sugar and milk.

In a previous paragraph, dewpoints were men-

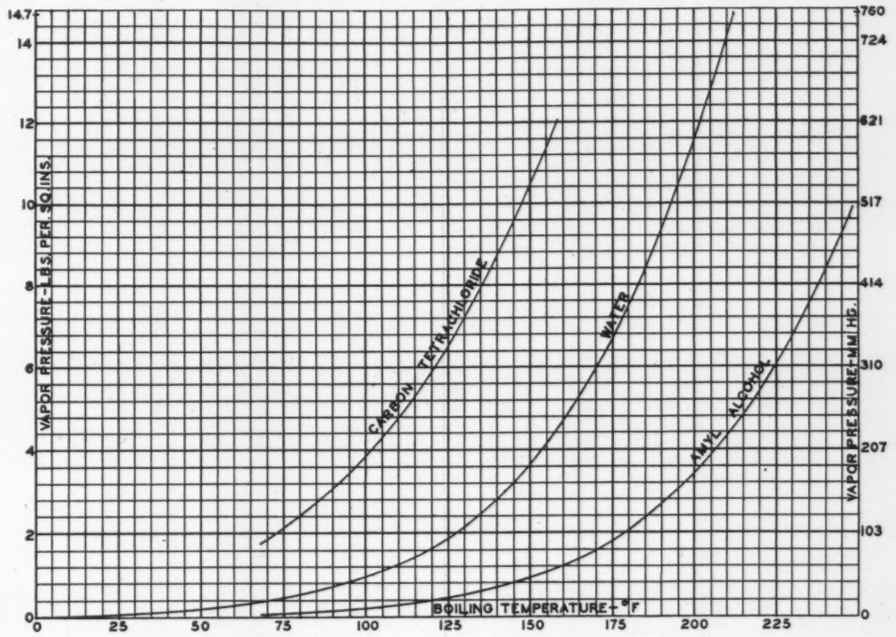


FIG. 2—EFFECT OF PRESSURE ON BOILING POINT

tioned. Dewpoint is the temperature of a saturated air-water vapor mixture which would contain exactly the same amount of moisture as exists in another mixture at a higher temperature but at a relative humidity below 100 per cent. Because vacuum drying involves closed containers it is not so easy to determine dewpoints as under atmospheric conditions. At the same time it is possible to know the initial condition, as far as moisture is concerned, of the material to be dried and of the air in the drier. It is then possible to figure the theoretical dewpoint and to check the calculations by measuring the moisture actually removed.

No field in which vacuum drying is used has exploited this method of drying so successfully as the oil industry. In recent years the improvement of cracking processes has involved the reduction of the actual pressures, absolute, which were formerly employed and now much greater quantities of distillates, such as gasoline, benzene and kerosene, are produced from a given quantity of crude oil. This has not only met the rising demand for these distillates but has increased the revenue obtained from the wells.

Drying under any condition is dependent on the vapor pressure of the moisture in the material to be dried, which moisture must be vaporized in order that it may be removed, and the pressure of the air in the surrounding atmosphere. In order that the removal of moisture may occur, a difference in these two partial pressures must exist so that the pressure of the moisture in the material is greater than that of the air. Where there is equilibrium, both pressures have the same value and neither the air-water vapor mixture surrounding the material or the material itself can take up moisture. Therefore the condition for maximum speed in drying will be had when the pressure surrounding the material is at the lowest possible point. It follows that any drying process must be efficient in destroying the equilibrium which constantly tends to re-establish itself.

In vacuum drying the destruction of this equilibrium is secured by constant and efficient removal of the vapors which are forming. This is accomplished by constantly dropping the boiling point of the moisture within the material by lowering the vacuum and, at the same time, by maintaining a constant temperature within the material from an outside source. Naturally, as the vacuum is established, convection of heat decreases to zero and the only heat which can be transmitted through space in the drier is radiant. Also, as less and less vapor is removed, less heat is lost from the drier. Even crude observations will often show a marked decrease in the steam consumption, as well as a marked decrease in the temperature on the surface of the piping at the vacuum outlet, in the first half hour of operation. As long as the partial pressure of the moisture is less than the pressure equivalent to its temperature it will continue to vaporize. If sufficient heat is not obtained from the external source, heat will be taken from the liquid and the vapor pressure will approach equilibrium. Therefore sufficient heat must be supplied from the external source, not only to continue vaporization but also to speed up the drying of the material.

Certain conditions are necessary in order that economy in heat supply may be realized. One is the use of low pressures, where steam is employed, or of electrical energy where such energy can be applied near the center of the material. Another is the rapid removal of condensate, through the most efficient traps which can be secured, where steam is used. A third is adequate insulation for the vacuum drier. The last is a highly polished surface for the interior of the drier in order that the radiant heat may be reflected back to the material constantly.

Welded joints are very satisfactory for vacuum driers. Vacuum outlets are usually made too small; they should be bell shaped at the drier and larger than necessary in order to avoid loss of capacity due

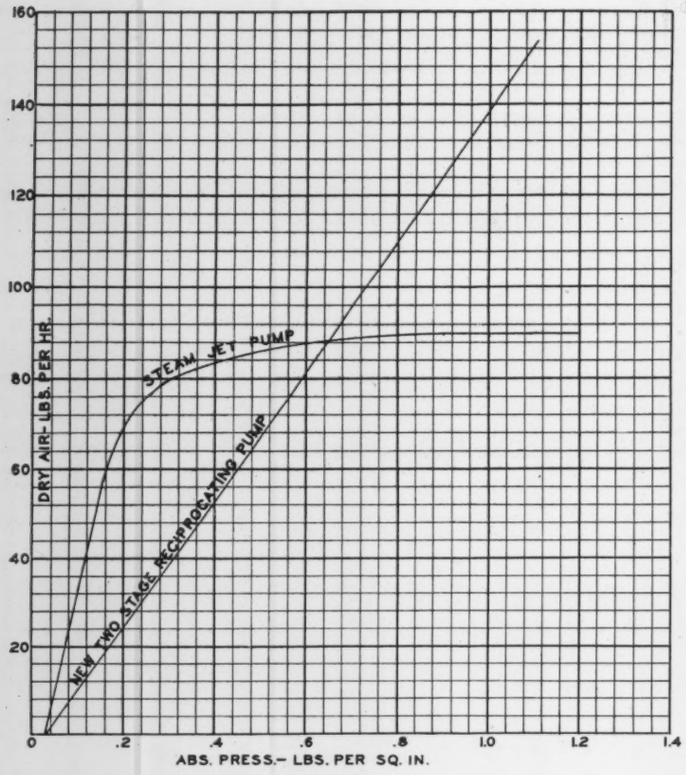


FIG. 3—TYPICAL VACUUM PUMP PERFORMANCE

to friction. Piping and fittings should be tight. Two pipe mains are needed where two or more driers are installed so that maintenance of vacuum can be kept separate from starting operations. Pumps of the rotary type are satisfactory for ordinary vacuum but the reciprocating type is frequently used where a so-called higher vacuum is desired. Where a pressure below 1 lb. per sq. in. or 100 mm Hg absolute is needed, a steam jet pump should be used as an auxiliary to the reciprocating pump. In recent years condensers have gone through much development and, where reasonably cool water can be had, high condensing efficiencies are now possible through the use of the counter current principle. Receivers should be baffled to prevent the incoming moisture from short circuiting from inlet to outlet and thus decreasing the vapor handling capacity of the pump.

The operation of this equipment requires ordinary skill and detailed operating instructions. One difficulty which is likely to develop in installations of more than one drier is the splashing of moisture into a drier which has already been evacuated. Here is the reason for two mains and also for care in the opening and closing of valves. Most of the moisture removed from materials dried under a vacuum comes off in the vapor form in the first half hour. This vapor partially condenses in the piping. If one drier is started on the vacuum pump and another drier, previously evacuated, is on the same line or main the second drier's vacuum will come to equilibrium with that of the first drier and moisture from the first will be drawn into the second. This moisture may have picked up oil in transit and the resultant mixture may do serious damage to materials in the second drier.

The multiple-effect vacuum drier furnishes an interesting method, especially for liquids, of drying. Take a three-effect layout for the purpose of illustration. Let saturated steam enter the first effect at 12 lb. per sq.in. absolute pressure and a vacuum of 9 lb. per sq. in. absolute (517 mm Hg) be maintained. The steam temperature would be 202 deg. fahr. and the water content of the liquid in the first effect would boil at 187 deg. fahr. to furnish steam to the second effect. Let the vacuum in the second effect be 5 lb. per sq. in. absolute (258 mm Hg) and the water in this effect will boil at 162 deg. fahr. to furnish steam to the third effect. In this latter effect let a vacuum of 2 lb. per sq. in. absolute (103 mm Hg) be maintained and the water content of this liquid will boil at 127 deg. fahr. This vapor will pass into the condenser. The condensate in the second effect must be pumped out because it is under the pressure of the atmosphere. Also, for the same reason, the vapor from the third effect and the condensed water in the condenser must be pumped from the system. The condensed steam from the first effect may also be led into the heating coils of the second effect where part of this condensate will flash into steam due to the fact that the pressure is below atmospheric.

Leakage is one of the most serious problems in the maintenance of vacuum. A loss of 1 lb. per sq. in. per 24 hours after the drier has been evacuated and the pump shut down is sufficient to necessitate careful examination and stoppage of leaks. These leaks can be located, while the vacuum is on, by the use of a light asphaltum paint. Pin holes in the surface of the paint will show the exact location.

The reader will find information of interest in the two curves shown in Fig. 3 which give the characteristics of the reciprocating and the steam jet vacuum pumps. The curve for the reciprocating pump can not be maintained long as friction will reduce the efficiency.

The Grinding of Valve Seats and Discs

Regulating valves for use on compressed air pressures should have their seats and discs ground in specially for compressed air pressure. Large regulating valves for use on steam pressure, after the seats and discs are ground in and as a final test, should be heated with steam and while still hot given additional grinding so that the seating faces will be faced together as nearly as possible under actual operating conditions.

Regulating valves usually work well and hold tighter when used on compressed air pressure. A carefully ground-in regulating valve, or one with rubber or leather-faced discs for compressed air pressures should, if properly assembled and adjusted, hold a steady and uniform reduced pressure as required, within a reasonable range of its adjustment, when working against a "dead end," that is, with no pressure flowing through the valve.

Improved Electrical Properties by Drying

By R. F. Morrison

Article No. 1

IN THE design of electrical apparatus, insulation is an important factor. It furnishes the one safeguard against otherwise serious losses of current. In the power field these losses are not important in many cases, since the losses are but a small fraction of the total current carried. Much of the insulation in this field is impregnated under a vacuum with compounds which afford a fair protection against moisture regain. It is in the low potential field where insulation problems are acute. Here the stray currents are likely to represent an important part of the total current employed.

The low potential field was slow to develop. In the past its greatest growth has been in the telephone industry. Today radios and apparatus for testing purposes are examples of developments of major importance in low voltages.

Leakage in this low potential field has necessitated larger installations. Leakage may reduce the transmission of the human voice to very short distances. Worst of all it can be responsible for inferior quality. This means inferior electrical characteristics. Since leakage is always due to poor insulation, moisture or dirt, the early efforts towards its elimination were mainly directed towards improvement of insulation as far as materials were concerned. Later, various forms of atmospheric and vacuum drying were used. Today, with the growing scarcity of materials to meet the increasing demand for more and better apparatus, only the very best facilities of the drying and air conditioning industry will give the quality required. It is with this need that we are concerned in the following.

Various Methods Used to Stop Electrical Leakage

To overcome electrical leakage, lacquers have been used with a fair degree of success until high humidities were encountered or until the lacquer either cracked or was scratched off. Paraffin and beeswax were also used with less satisfactory results due to the crystalline nature of the materials under even normal temperature conditions. Various other methods and materials have been used from time to time as a remedy for surface leakage. These usually involved the use of chemicals supposed to adsorb moisture in the surrounding air-water vapor mixtures. Their main shortcoming was that they did not give uniform results.

Factors That Affect Electrical Leakage

Electricity has the peculiar property that it can move through or over some materials but not others. Those of the latter class are known as insulators. Perfectly dry air is the best of all insulators. When this same air becomes humid, a small portion of its moisture condenses on exposed surfaces of materials with which the air comes into contact. Where these materials are hygroscopic (as are many commercial insulators such as paper, calico, linen and fiber) this moisture is picked up or adsorbed. In the case of insulators, such as glass and porcelain, it remains on the surface in the form of a film which can not be seen by the naked eye. Since water is one of the best conductors, surface leakage will occur under the conditions just named until a change in temperature or humidity causes the moisture to disappear in the form of vapor. Since part of the current flows through the moisture on the surface, and a much smaller part flows through the conductor, the amount of leakage current may be very great. It is also well to keep in mind that the electrical conducting power, or conductivity, of a non-insulator varies with the temperature.

A peculiar property of insulators, or dielectrics, is that a thick layer has less strength to resist the flow of electricity, or a given difference of potential, than a thin layer. As a result condensers, as an example, are made up of many layers of paper or tin foil and telephone cables are constructed of copper wires insulated with spirally-wound paper.

Effect of Moisture on Insulation of Telephone Cable

The most thorough study of the effect of moisture on insulation has been made in the electrical cable field where alternating currents are used. For this reason it is best to confine all theoretical discussion to this product with special attention to telephone cable. While the theory involved may be somewhat different, due to peculiarities of design, the fundamental principles are the same and the effect of moisture is serious whether the surface is flat or round.

There are four primary factors which must be defined in any consideration of the theory of the telephone. They are capacity, conductance, inductance and resistance. They may be defined as follows:

Capacity (C). The electrical charge which must be imparted to a body to raise its potential by one unit when all its neighbor conductors remain at zero, unit-farad.

Conductance (G). The current flowing in a conductor when unit potential difference is applied at its terminals, unit-mho.

Inductance (L). The total flux per unit of current which is linked with the circuit, unit-henry.

Resistance (R). The obstruction to the flow of electricity, unit-ohm.

If a cable of infinite length has a current strength

of I, at one point and I_2 at a second point separated by the distance l and if phase difference is disregarded, the relation of these current strengths can be expressed as follows due to the damping effect:

$$\frac{I_2}{I_1} = e^{-\alpha l}$$

$$\text{or } \alpha = \frac{1}{l} \log_e \frac{I_1}{I_2}$$

$$\text{Hence } \alpha = \frac{1}{l} \times 2.3026 \log_{10} \frac{I_1}{I_2}$$

In the case of a loaded telephone line the primary constants previously explained may be used to define the constant α for:

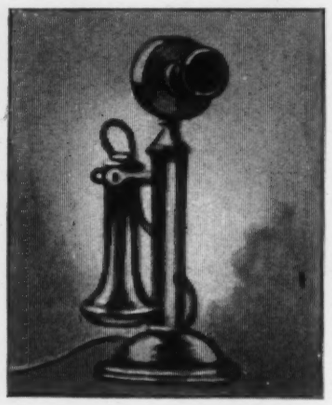
$$\alpha = \sqrt{CL} \left(\frac{G}{2C} + \frac{L}{2R} \right)$$

The expression $\frac{L}{2R}$ is known as the series characteristic of the cable and is fixed by the nature of the loading. It is not affected by moisture. The expression $\frac{G}{2C}$, which is known as the damping constant, the shunt characteristic of the line, represents the energy loss in the dielectric (or the dielectric effect) and is markedly affected by the presence of moisture. The expression $e^{-\alpha l}$ is known as the attenuation factor, as it represents the diminishing strength of the current due to damping, and α thus becomes the attenuation constant.

It readily will be seen that the factor $\frac{G}{2C}$ is not controlled by design but can be controlled by proper drying. Also it is evident that an improvement in $\frac{G}{2C}$ will give a corresponding improvement in α or that the elimination of moisture will reduce the damping effect on the current in the line.

Professor J. A. Fleming is authority for the following table of values of $\frac{G}{2C}$ usually found in practice:

Dry core paper telephone cable at 15 deg. Cent.	9.0
Dry manila paper at 19 deg. Cent.	20.8
Pure India rubber at 18 deg. Cent.	15.0
Vulcanized India rubber at 17 deg. Cent.	6.0
Ordinary gutta-percha at 15 deg. Cent.	58.5
Improved gutta-percha	6.0



Loading of telephone cable already has been mentioned. In 1887 Oliver Heaviside pointed out that "when an electric wave of complex wave form travels along a telephone wire, the higher harmonics into which the wave form can be resolved, attenuate or die out more quickly than the lower or fundamental wave and also that they travel more quickly." This results in distortion of the wave form. Where the inductance is increased to equal the product of the capacity, the copper resistance and the insulation resistance, this can be prevented. This is true where

$$\frac{R}{L} = \frac{G}{C}$$

Heavisides' distortionless cable has been mentioned. To obtain an approximation to such a cable, a number of solutions can be had. One is to increase the conductance or the inductance, the second is to decrease the capacity or the resistance and the third is to make CR equal to GL as nearly as possible.

Long Distance Communication Made Practicable in 1899

Professor Pupin, in 1899, loaded telephone cables at regular intervals with inductance, or loading, coils, and showed that any required inductance could be secured by means of toroidal coils with divided iron cores. These coils doubled the range of the telephone and made long distance communication practicable.

It now easily can be seen how necessary it must be to hold the moisture in telephone cable to a minimum. The drying of the cable core, the protection of the dried core from moisture pickup until it can be sealed and the drying of the loading coil become important steps in the production of first class cable. It is also easy to understand how important a function drying must hold in the production of any low potential electrical apparatus.

Insulation of Piping for Railroad Work

WITH the increase in size of central power plants and on account of the increased steam temperatures now being used, the demand for a satisfactory high temperature insulation has grown steadily. Eighty per cent of magnesia is unsuitable for temperatures over 600 deg. fahr. At the same time the average high temperature insulation is not sufficiently effective, so that on other than small pipes it is not entirely satisfactory. The importance of the problem is indicated by the development of means of applying next to the pipe a layer of high temperature insulation of varying thickness to meet the individual condition by apportioning the thickness so that when the temperature gradient has been reduced to a point below the maximum working temperature of magnesia, magnesia may be satisfactorily applied over the high temperature insulation in the same manner that double standard thick magnesia with broken joint construction would be applied, using standard size magnesia sections.

One of the most prolific losses of heat in the average power plant is through the fittings and flanges where these are often left uninsulated. Below is given a table showing the equivalent length of pipe per extra heavy flange and the equivalent length of pipe per extra heavy fittings for various sizes of pipe:

Nominal Pipe Size I. D., Inches	Flanged Coupling		Long Radius Ell		Tee	
	Area Sq. In.	Pipe Lengths, Ft.	Area Sq. In.	Pipe Lengths, Ft.	Area Sq In.	Pipe Lengths, Ft.
2	.848	1.363	2.16	3.474	3.09	4.968
2½	1.107	1.463	2.76	3.665	4.05	5.378
3	1.484	1.619	3.74	4.08	5.33	5.815
3½	1.644	1.57	4.28	4.087	6.04	5.768
4	1.914	1.624	4.99	4.236	7.07	6.001
4½	2.04	1.558	5.46	4.170	7.72	5.897
5	2.18	1.497	6.02	4.134	8.52	5.851
6	2.78	1.603	7.76	4.475	10.64	6.136
7	3.46	1.733	9.73	4.874	12.33	6.177
8	3.77	1.670	11.09	4.913	14.74	6.531
9	4.44	1.762	13.17	5.228	17.23	6.48
10	5.20	1.846	15.60	5.538	20.41	7.245
12	6.71	2.01	18.76	5.622	26.65	7.987

Flanges and fittings may be insulated either with removal covers built up on the job, with cement, or with permanent covers composed of blocks of sectional pipe covering of the same material as is used on the pipes.

The insulation of railroad yard piping is an important subject, and the type of insulation depends upon the location of the piping. There are several ways of taking care of insulation underground. The most common of these outside of the concrete trench is the tile pipe conduit such as is specified on New York state work, where guaranteed efficiency of 90 per cent is required. The type of job generally used to meet this condition consists of salt glazed and vitrified conduit, which is split and through which the pipe is placed, the pipe being supported on cast iron roll frames. The insulation used to surround the pipe is made of asbestos fiber and a material of sponge-like nature.

In conduit where return lines are installed and are under vacuum sectional covering is used on account of asbestos fiber getting into this line, if there is a break. The underdrain laid with open joints carries away the water that rapidly filters away from the system through the broken stone or gravel in which the lower half of the system and the underdrain itself is laid. Where such expensive construction is not desirable, a sectional pipe covering, which is vitrified, has been used on several government jobs. In the selection of insulation its efficiency for the job must be considered.

The same insulation that will prove most satisfactory for overhead yard piping will prove the best material to be used in concrete trench construction or as an insulator for pipes located under platforms or under canopies. Insulation used for these purposes should be one having a relatively high insulating efficiency in view of the fact that extreme weather conditions will be encountered because the piping is outdoors, and, at the same time, an insulation having considerable mechanical strength, as it must stand up under vibration and moisture conditions. In view of these reasons, insulation soluble in water, or insulation of poor mechanical construction, should not be used.

At the same time the insulation should be provided with a waterproof jacket applied to the covering during manufacture, so that there is no possibility of pockets and separations of jacket from the insulation. Where desired, this covering may be protected from the blast of locomotives with a metal jacket, but, unless subject to severe abuse, this will not be needed at any other point.

With the use of hose for steam heat connections to cars, the question of insulation has not been overly important, due to the fact that the rubber and duck in the hose has some insulating value, but with metallic connections the heat loss through the connector has increased considerably and question of insulation must be given considerable thought.

Some sectional pipe covering has been used for this work. However, a covering should be selected which will stand abuse. An asbestos felted material approximately ¼ in. thick, protected by a wire inserted jacket, is used. This material is applied in tape form, wrapped on and held in place by copper wire spiralled on approximately every 2 in., with two close turns every 6 in. soldered. Blower pipes in an engine house which are subject to abuse are protected by this insulation.

This information was abstracted from a paper presented at the 1929 meeting of the International Railway Fuel Association.

Tendencies in District Heating

By Prof. C. H. B. Hotchkiss

FIG. 1—NEW HEATING PLANT OF THE ALLEGHENY COUNTY STEAM HEATING CO., PITTSBURGH, PA.

THE business of supplying heat to buildings as a utility enterprise has reached its present status through a gradual development over a long period of years. During this period there have been times of activity and expansion as well as times of retrogression. Ideas, inventions, changes in ownership, changing ideas in management, and changes in the general life of communities have all been reflected just as truly in this business as in most others. Out of it all has come the business as it exists at present. In view of this, probably the best way to get a clear picture of things as they are is to glance briefly at some of the more outstanding features as revealed by the past.

First Central Heating Plant

The actual beginnings of the practice of supplying heat from a central plant antedates the supplying of electricity from such plants. The first heating plant started operating in the '70's. It was a steam plant and steam heating was used in the buildings. Naturally, it was a purely heating plant and was not connected with electric generation in any way. It is also interesting to note that it employed a pressure which at that time was moderately high. Steam was carried underground from the generating plant to the buildings. For some years following the successful operation of this plant, a considerable boom developed in the extension of such plants. These were operated with varying degrees of success.

In the late '80's, the first installation using hot water underground made its appearance. The argument in favor of this method was that of utilizing the heat in the exhaust steam from engines to heat hot water in the generating plant. This hot water was then pumped to, and through, the buildings to be heated. The point of most interest in connection with this method is not that it *used* the heat of exhaust steam—for a steam system would do the same—but that in its actual usage it served to ally the supplying of heat very closely with the supplying of electric service. It served to draw the attention of the rapidly expanding electrical industry to the close relationship between central station heating and central station electric service.

Relation Between Power and Heating Realized

Here began one of the features which has greatly influenced the course of development of central station heating. As soon as the close relationship between the two services was fully realized, they began to develop together. Many electric utilities installed a heating service operating on the heat contained in the exhaust from their engines. Rates for such heat were often ridiculously low, long-term contracts to supply heat at set figures were entered into, and the heating service was often used as a means of securing electrical business. In general, the business of supplying utility heat was linked to the business of supplying utility electricity.

Growth of Utility Heating Checked

Scarcely had this taken place before the growth of utility heating was noticeably checked. So long as reciprocating engines were used for electrical generation, and so long as the generating plants were located close to a heating load, the combination of electric generation and exhaust-steam heating lived rather peacefully together. Soon, however, the turbine made its appearance and the use of high vacuums was developed. The turbine was most attractive when installed in large units and when operated at high vacuums. This required the extraction of the heat of vaporization at the generating station, and made it necessary to transfer the heat formerly used for heating to the condenser cooling water. This cooling water was often at too low a temperature to be useful as a means of heating buildings.

Moreover, the tendency was to build the generating stations at points distant from the heating load. As a result of these, and other, conditions the growth of electrical generating plants with exhaust-steam heating was checked. In many cases the existing plants were, however, operated and continued to furnish heat. Very often, though, the electrical load developed so rapidly and furnished so attractive a return that attention was turned to it almost to the exclusion of heating. The

low rates charged for heating, and the long-time contracts also conspired to throw the heating function into disfavor.

This period may be said to represent one of stagnation and even of decline of utility heating. This period, generally speaking, ended some ten to fifteen years ago.

Recent Tendencies

Since that time there has been a marked revival of interest and of growth in district heating. This later period has been marked by several noteworthy features.

First of all, there has been a fairly general realization that the supplying of a building-heating service can be made to pay for itself when reasonably well planned and conducted. The realization of this fact has tended to make the managements of electric utilities disposed to consider the heating as something other than a nuisance.

Another notable point is that the use of hot water as a carrier of the heat has greatly declined. Not only have hot-water systems not been built in recent years but a sizable number of those in existence have been changed to steam, although the use of hot water has much to recommend it from the utility standpoint. Perhaps this general decline of district hot-water heating has been the most clear-cut feature of the new pediod. It has not been universal, however.

Heating Divorced from Electric Generation

During the past ten years there has been a tendency to divorce the heating entirely from electric generation. As a result, many of the newer plants have been built as purely steam-generating plants delivering their entire heat output into the heating lines as steam. Where district heating is conducted by a corporation independent of the electric utility, its generating plant is often, indeed nearly always, of this type. This practice represents a considerable swing away from that which originally brought the two services into contact. It is interesting to note, however, that such plants were used when district heating first started, and that consequently the idea of steam-generating plants apart from electric generation is not a new one. Like their predecessors, these plants operate on what may be called moderate pressures. Recent examples of plants of this type are those in New York and Philadelphia.

Electric Generation Incidental

We have already noted the fact that early use was made of the idea of extracting both electric energy and heat from steam. This practice is still in use but the newer plants are arranged with an important change in their design. The older plants were intended to be primarily electric stations which used the exhaust for heating purposes. The newer plants are intended to be primarily heating plants which use some of their heat to produce electricity. In the new type of plant, the electrical generation is quite incidental to the primary purpose of furnishing steam for heating. In these plants, the basis of the load is the demand for steam for heating and not the demand for electrical energy. The turbines essentially act as reducing valves. They deliver their electrical output to the electric distribution system. On occasion, the turbines can be cut out entirely and the plant would then operate essentially as a heating plant. Recent examples of such plants are those in Rochester, N. Y., and Pittsburgh.

At the present time, then, we have a decided tendency toward growth and development in utility district heating with hot water dropping out of use and with the steam being generated in plants of one of two general types. Many of the older systems are still in operation, however. The map in Fig. 3 gives a good idea of the present extent and distribution of district heating with some 300 projects in existence.

The recent growth of district heating has also been marked by at least two other features which differ from its earlier expansion. In the first expansion in the early '80s, many of the developments were in small towns and in residential districts. During the growth which has marked the past ten years, the expansion has been greatest in the business districts of the larger cities, with the load being furnished largely by hotels, theaters, office buildings, apartments, and retail stores. Fig. 2 shows graphically this variation in the growth. Heating services operating in the downtown districts of the large cities are able to secure customers whose demands are heavy and to reach whom it is not necessary to install distribution lines of excessive length. Loads such as these probably represent the most highly desirable ones possible to reach with a heating service. The fact that these concentrated load areas account for much of the recent growth of utility heating does not mean that such services for small communities are unprofitable, or likely to disappear. It merely means that those operating in these areas have grown and have been financially successful. Many of the smaller plants are located in less

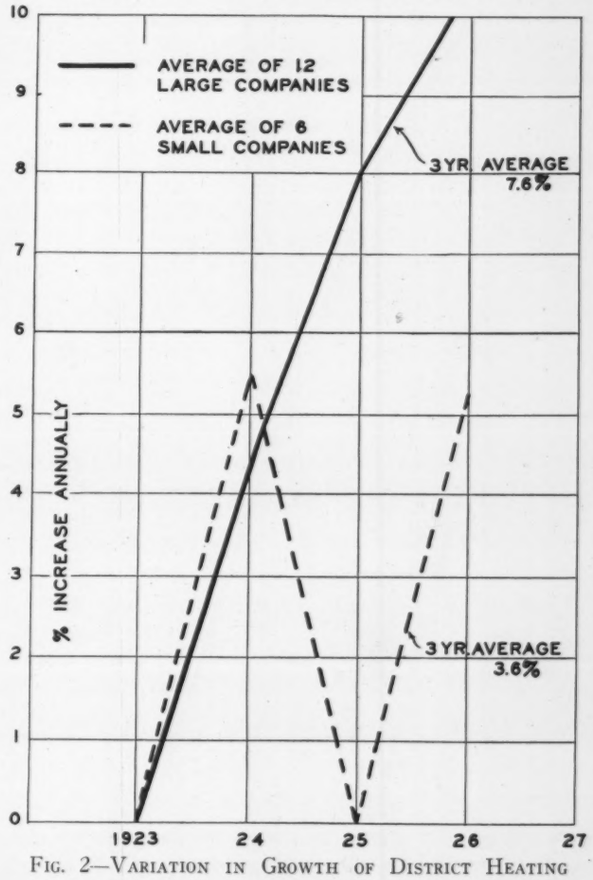


FIG. 2—VARIATION IN GROWTH OF DISTRICT HEATING

FIG. 3—THE DOTS SHOW THE EXTENT OF DISTRICT HEATING. THE PLANTS INDICATED REPRESENT AN INVESTMENT OF MILLIONS OF DOLLARS INVOLVING THE OPERATION OF HUNDREDS OF MILES OF UNDERGROUND MAINS, BOTH LOW AND HIGH PRESSURE. THESE PLANTS ARE OPERATED BY PUBLIC UTILITIES, MUNICIPALITIES, COLLEGES, UNIVERSITIES, INSTITUTIONS, AND MANUFACTURING PLANTS

rapidly growing districts and consequently their loads have not developed so rapidly.

However, there does appear to be a decided tendency on the part of some utility managers to discourage extension in purely residential districts, although there have been some recent cases of extensions into such places. It may be taken as almost self-evident that the cost of heating in such districts would be higher than in the denser load areas if similar methods were used in each case. It would seem that extensions to residential districts would call for special methods both of generation and of distribution. Interesting developments have taken place in "block" or community systems. Apparently the general tendency is to treat the furnishing of a heating service to a scattered residential district in a somewhat different fashion, and by other interests, from that or those used in dense, downtown business centers. Probably such a policy has much to recommend it and we may look for it to continue.

Supplying Demand for Process Steam

The recent success and growth of the heating services of some of the utility companies probably has had considerable to do with the beginning of a movement which is just appearing. For some time the tendency has been to generate electricity in huge central turbine-driven steam stations. Increasingly large plants have been built and increasingly large turbine units have been operated. All have been operated condensing and almost invariably the condenser cooling water containing much heat has been wasted. Recently attention has been turned once more to the problem of securing some use of this heat, while still getting good economies from the turbines. The problem is of long standing, but is now being approached from a rather new angle. The idea is to locate utility generating plants at or near industrial plants which have a heavy demand for hot water and process steam. If such plans work out successfully, the value of a steam generating plant which utilizes the latent heat may be better demonstrated and the utility heating plant with electrical by-product generation may be reappraised at higher values than have been assigned to it in the past. This tendency, now just starting, holds much of hope for the future development of building-heating services by utility companies. Far from being merely temporary, the recent growth of district heating bids fair to be long sustained.

Relation of Utility and Contractor

At present the relation between the utility and heating contractor is that the one agrees to furnish steam at an agreed upon pressure to flow through the heating system, which the other has agreed to install. The function of the heating system is the same whether the building is to contain its own boiler or is to be supplied with street steam, as either may be adapted readily to the steam-heating systems in use. Where, as is so often the case, the contractor makes the layout and is left to decide on matters of piping, it is mutually advantageous to the contractor and the steam company to interchange information. Such co-operation between the heating contractor and the utility results in decided benefits to both, and, consequently, to the ultimate consumer.

Dust and Ultraviolet Light

That dust in the atmosphere shuts out the health-giving ultra violet rays of the sun is a well-founded belief, according to three Baltimore investigators who reported to the American Journal of Public Health the results of experiments made in the city of Baltimore and in the country around it.

Cups to catch the dust settling from the atmosphere were placed in the center of the city, in the near suburbs and in farms about 10 miles out in the country. Calculations from the contents of these cups showed that the total solids in the atmosphere for each of the three areas amounted to 1,800 tons per square mile per year in the city; 800 tons in the suburbs and only 340 tons in the country.

Then the amounts of ultra violet light in each area were carefully measured and checked by several methods and it was found that the amount was 50 per cent greater in the country than in the city. Measurements at the top of a tall building showed more ultra violet light than at the street.

Controlled Indoor Atmosphere—High Lights of Its Development

By Perry West, Consulting Engineer

WEATHER is a subject which has been of unusual concern to mankind throughout the ages and the subject of the control of indoor atmospheres has enlisted its attention for many centuries. Man has evidently been thinking and talking about his atmospheric environments since his beginning and although it is one of the five important items which go to make up the conditions of health, comfort and efficiency of life, it has, until quite recently, been the least developed.

Food, water, clothing and shelter are the other four and while one can exist without food or water for days, and without clothing and shelter indefinitely, one can exist for a few moments, only, without air. There is no wonder, therefore, that we remember, even as children, of hearing our fathers and grandfathers talk about the weather; what kind of a day it would bring forth, what effect it would have on the health and comfort of the family and how it would affect the crops and the products of the farm or shop. The weather, therefore, both indoors and outdoors, has been a subject of vital concern and of universal conversation throughout all times and yet, as we have said, it is only within quite recent time that anything really worth while and lasting has been done about it.

There is fast developing in this country a controlled air mindedness, and experience shows that those who are responsible for the air conditions in our public buildings are coming more and more to request real controlled air instead of makeshifts.

Dilution Theory of Ventilation

The first efforts to study and control atmospheric conditions came after the experiments of Peclet, Dr. Black and Priestley about 1750 which showed that the breathing of air by animals reduced its oxygen contents, and increased its carbon dioxide content, so that the air of occupied rooms would finally become devitalized from loss of oxygen and vitiated by the addition of carbon dioxide to a point where it would cause drowsiness, discomfort and injury to health. This theory was perfectly sound and logical if carried to the point where the results predicted might be substantially produced, but unfortunately it was not checked with actual practical conditions far enough to show that this rarely ever happened under usual conditions. From this and similar theories of succeeding scientists the dilution theory of ventilation was worked out on the basis of supplying sufficient quantities of outdoor air to keep the carbon dioxide content of the indoor air down to eight parts per million by volume.

This continued until the time of LeBlanc (1842), Bernard (1857), Von Pettenkoeffer (1862), Hermans (1883), Billings (1884), Mitchell and Bergey (1895), and Flug (1905), practically all of whom suspected that the increased carbon dioxide contents of the air was not the fundamental cause of discomfort or injury to health from ordinary vitiated atmosphere. Some of these, especially Von Pettenkoeffer, advanced the theory that effluvia and other organic poisons exhaled with the breath or exuded from the body caused the evil effects of the air in crowded spaces.

These later theories were never proved and as a result the original theory of trying to control the indoor atmosphere by supplying a large volume of air on the quantity basis rather than on the quality basis was in vogue from the time of Dr. Black until about 1910. In all of this time, and especially in its last two decades, the use of mechanical ventilation had increased tremendously, due to the great number of large schools, hospitals, public buildings and commercial structures being erected and the quantity theory seemed to have become firmly established. It should be noted in this connection that while the evil effects of carbon dioxide had been discarded by all of the accredited workers on this subject it was still used as the index of the indoor air conditions and that a very close connection was established between this and the stuffy condition of occupied spaces.

Criticisms Appear

At the annual meeting of the American Society of Heating and Ventilating Engineers in New York, 1911, Dr. W. A. Evans of the Chicago Board of Health and Dr. Luther H. Guilich of the Russell Sage Foundation presented a most scathing criticism of ventilation as it was then practiced. It was forcibly brought to light for the first time at this 1911 meeting that the great majority of mechanical ventilating systems installed in hospitals, schools, public buildings, etc., were not efficacious and did not produce the comfortable and healthful indoor air conditions desired.

One important conclusion reached at the meeting was that while the heating and ventilating engineers had been continuously improving and refining the mechanical apparatus and were in a position to furnish most any condition of indoor atmosphere desired, the doctors and physiologists had made little or no progress in the matter of determining just

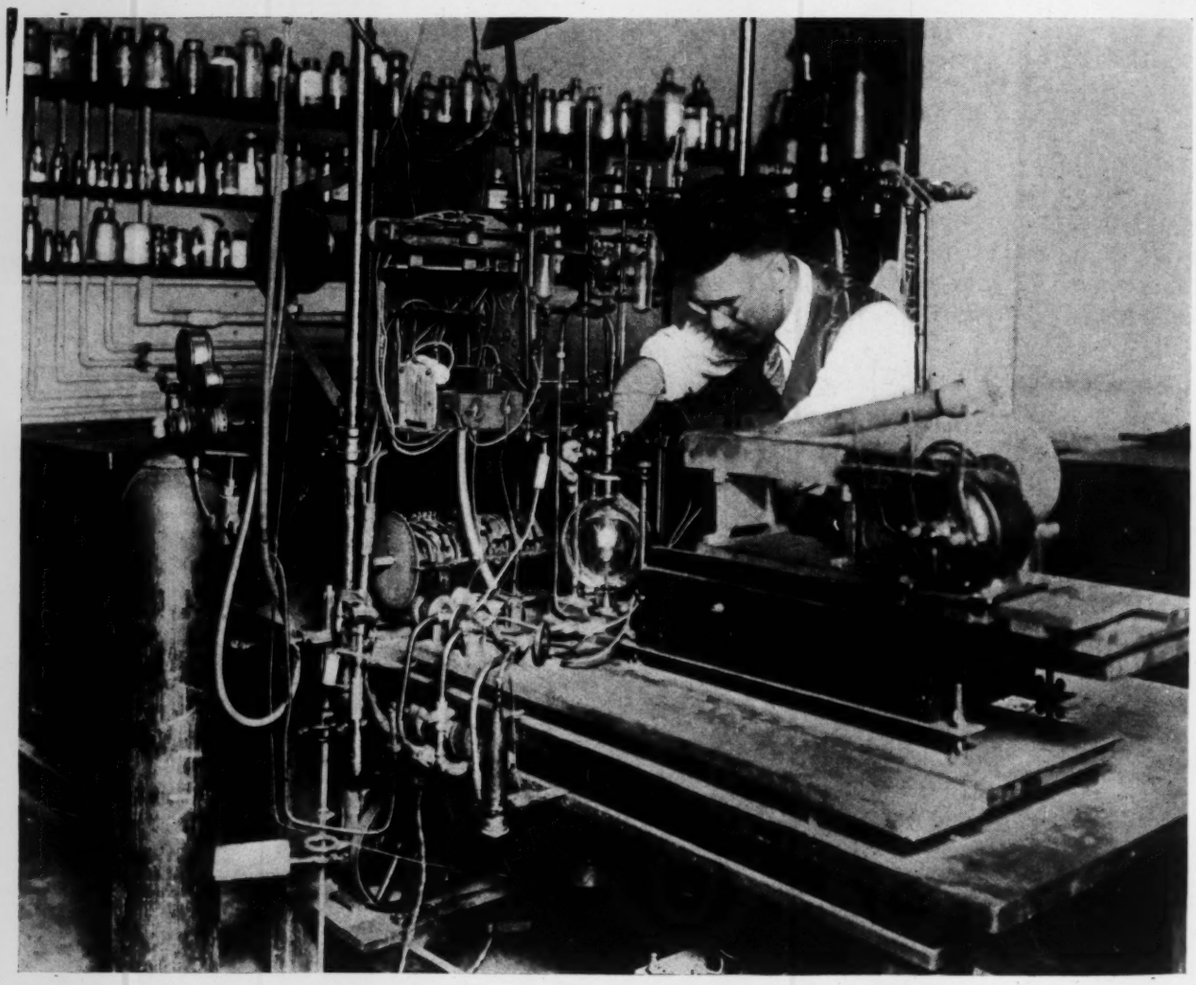
what atmospheric conditions were best suited for the maintenance of proper indoor ventilation. The engineers had previously proceeded on the theory that the supplying of a sufficient quantity of reasonably clean air from out-of-doors and the exhausting of a proper quantity of foul air, with reasonable control over temperature and distribution, would constitute good ventilation. The doctors pointed out, however, that this old theory of ventilation, based primarily upon dilution for the purpose of keeping the carbon dioxide content and odors down to a certain point, did not produce satisfactory results. "Canned air" was the term applied to such ventilation and it was found to be enervating and deleterious to the membranes of the internal air passages.

Physiological Studies

Following a period of general dissatisfaction and lack of confidence there came a period of very active study and investigation by a number of doctors, physicists and heating and ventilating engineers. Among those whose work contributed materially in this connection to the present state of the art may be mentioned: Dr. E. Vernon Hill of the Chicago Health Commission, who has been connected with this development for the last 20 years, Dr. Leonard Hill of London who has been working on the subject for about the same period; Drs. Francis S. Lee and Ernest L. Scott of the Department of Physiology of Columbia University, who did notable work from 1914 to 1916; Dr. Wolff Freudenthal who has worked on the subject since 1900; Dr. James Alexander Miller who collaborated with the New York State Commission on Ventilation; Dr. Gerhard Cocks who also collaborated with the New York State Commission on Ventilation; Dr. Frederick W. Eastman of Columbia School of Medicine; G. W. Jones and W. P. Yant, chemists of the Bureau of Mines; and Dr. W. J. McConnell of the United States Public Health Service who co-operated with F. C. Houghten of the A. S. H. V. E. research laboratory; the late Dean John R. Allen, Dean F. Paul Anderson, Jay R. McColl, E. S. Hallett and W. H. Carrier, members of the American Society of Heating and Ventilating Engineers.

Soon after this new era of ventilation was entered upon the A. S. H. V. E. research laboratory was inaugurated at the United States Bureau of Mines in Pittsburgh and has taken a leading part in the establishment of new standards and methods of ventilation.

From 1911 until quite recently the disbelief in the old theories and the general dissatisfaction with the apparatus installed under these exerted such a disquieting effect in the minds of most people that the progress of air conditioning from the standpoint of comfort and health of human beings suffered a great



The United States Bureau of Mines Has Contributed Materially to the Present State of Air Conditioning

setback. As a matter of fact the results were such as usually occur when a long-established custom is suddenly swept away; i. e., a period of destructive criticism and the promotion of all kinds of untried substitute theories ensued. This has continued almost to the present time so far as the conditioning of air for the comfort and health of people is concerned, especially in schools, hospitals and other buildings of a public nature and wherever the deciding voice has rested largely with the laymen of committees and governing bodies who seem disposed, after the discrediting of the existing scientific theories, to formulate their opinions on this subject more from the standpoint of fad or fancy than from a more rational viewpoint.

This condition of affairs has not arrested the progress of air conditioning as much, however, as might be suspected due to the fact that during the time just prior to and since the old theories were upset another and perhaps more powerful influence has been at work along entirely different lines. We have said that the conditioning of indoor atmosphere was originally based upon the comfort and health of human beings from a purely humanitarian standpoint. This is undoubtedly the high and noble plane upon which it should be pitched and the one upon which it will eventually rest. During the reconstruction period, however, this high aim has frequently been lost sight of and more frequently missed altogether.

The weather has been a subject of vital concern and of universal conversation throughout all times, and yet it is only within quite recent time that anything worth while has been done about it.

Industrial Developments

Concurrent with most of the time that physicists and scientists have been working upon the problem of controlling indoor air conditions for health and comfort, there has been a much larger body of industrial and commercial laymen thinking just as hard but along different lines.

This dates back to the farmer who had to depend on the weather as to when and whether he could stem tobacco, rot flax or hemp, dry fruits and vegetables, or even bake the homemade cake or make the homemade candy. Along with this the manufacturer had always been a great slave to the weather conditions which, in a great many cases, prevented production altogether during certain seasons, slowed up or stopped production at other unexpected times, made certain processes prohibitive except in some out-of-the-way geographical locations, and in general made it impossible to run a full-time full-yearly schedule of production on most manufactured products.

This meant lost time for equipment and overhead, lost efficiency in workers, the laying off of skilled workers during inoperative seasons and the reorganization of forces afterwards. The manufacturer also noticed that overheated, stuffy, vitiated atmospheres detracted from the productive capacity of the workers. All of this meant economic loss and the manufacturers were quick to see the advantages of air conditioning and to employ it in business.

As a result of this air control mindedness on the part of industrial leaders the burden was taken up by them, where it had been laid down by the scientists and physicists, and carried forward in such a way as to have made great progress, not only from the standpoint of production and economy in the manufacturing field, but from the standpoint of the comfort and health of human beings as well.

A few of the accomplishments in these fields will illustrate what enormous strides have been made.

Industrial Applications

Prior to the use of air conditioning the textile industry, especially cotton and silk spinning and weaving, were at the complete mercy of the weather and was necessarily located in moist climate far removed from the warm, dry climates where the raw fiber is grown.

Under dry, cool climatic conditions fibers become brittle causing breakage, shutdowns, rethreading and other difficulties; static electricity collects causing fraying and tangling of the threads, explosions, etc.; fibers lose their ductility and uniformity of strength thus causing irregularity in cord, weave or other quality of product. Under excessively moist atmospheric conditions the fibers are flabby, the regain in moisture is excessive and the uniformity of product is destroyed.

To correct these difficulties and many others, including the very important standard testing of fibers, a uniform, automatically-controlled, warm, humid atmosphere is now used almost universally in these industries.

The rayon industry, which is one of the newest and completely chemical of the textiles, is dependent entirely upon a series of different automatically-controlled air conditions for the proper operation of its many processes.

In the confectionery industries the proper finish and gloss can not be formed, uniform formulas can not be used, dipping and coating can not be regulated, drying and boxing can not be continuously carried on, the cocoanut butter can not be prevented from exuding and forming a detractive white coating, and a number of other items of the process can not be done without proper air conditions. This has meant in times gone by that confectionery factories could operate during the cool seasons of the year only, so that production had to be speeded up, product stored, large forces of operatives organized and disbanded and schedules upset even during operating seasons.

To correct these difficulties most confectionery manufacturers are using a cool moderately dry controlled air around 68 deg. fahr. and 40 per cent relative humidity.

In the tobacco industry great economic waste has existed from crumbling of the leaf. Hand selection of leaves of the right moisture content for cigar wrapping, the curing of the tobacco in large open

barns subject to the vicissitudes of the weather have been in practice and the special drying, toasting, blending and curing of cigarettes have been impossible under natural atmospheric conditions.

With the advent of high-speed machinery for making one hundred billion cigarettes and hundreds of thousands of cigars per year these old conditions were impossible.

Properly conditioned air of a uniform moist nature is now correcting these difficulties and permitting such high speed machine production without the highly hygroscopic tobacco and paper becoming either too dry or too moist so as to destroy the uniformity of product or cause breakage and shutdown.

In the milling industry properly conditioned air is being used to prevent spores, mould, souring, caking or other difficulties encountered with modern high-speed milling machine operation and for securing such standardization of product as to establish an absolutely uniform product under any particular brand.

In printing and lithography the successive impressions of color-plate work will not register properly if the paper, which is highly hygroscopic, is allowed to absorb varying amounts of moisture. The inking rolls will swell or shrink with changes in the moisture contents of the air and exert varying pressures on the type with resulting irregular inking, the ink and rolls will become dirty from dust in the atmosphere and require frequent shutdowns to clean, static electricity will form and cause the paper to cling and slip if the air is too dry, and the whole impression will vary somewhat with changes in the atmosphere.

Properly conditioned air of a uniform temperature of 65 deg. and a relative humidity of about 50 per cent is being used to correct these difficulties.

In leather industries properly conditioned air is being most effectively used to keep shoe stocks of the proper flexibility while being made, to exclude dust and afford proper moisture during the drying of enamel finishes and for other purposes.

In bakeries it is being used to prevent mould and spores, to secure a uniformity of proofing, to prevent skin formation on the dough and for producing a clean sanitary atmosphere surrounding the product.

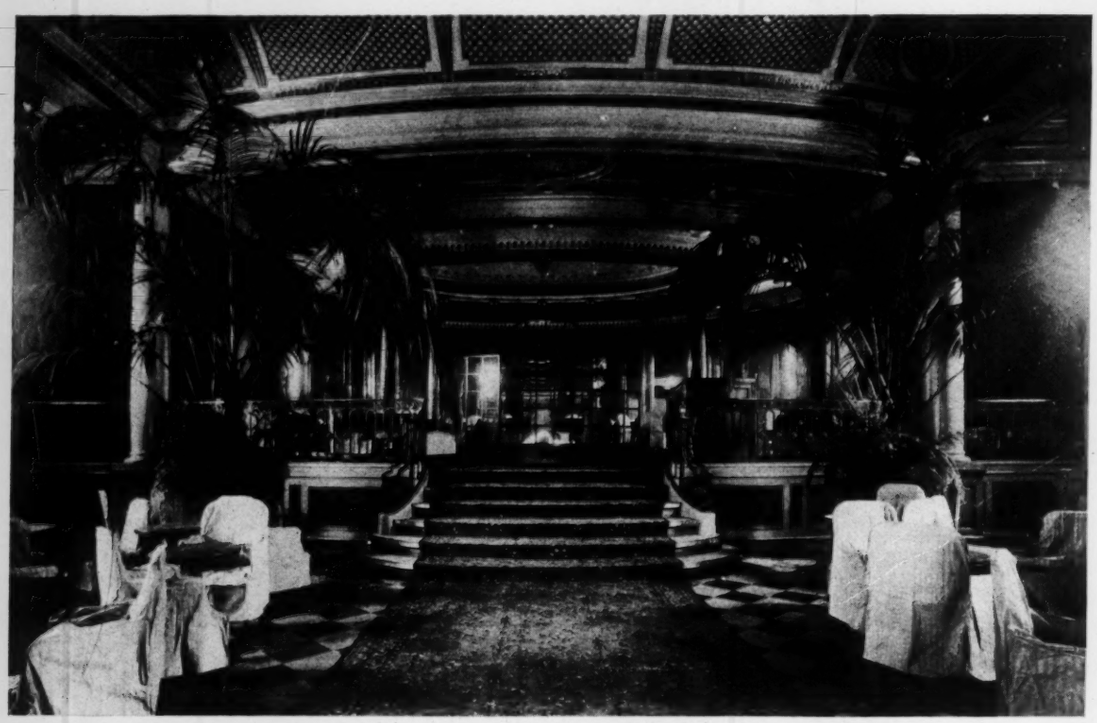
In the drugs and pharmaceutical industries it is being used to secure the proper cohesion and uniformity of weight in pressed tablets, for the proper drying of gelatines, coatings, capsules, etc., for securing uniformity in the size of pills for fitting into containers, etc.

In the food products industries it is being used to prevent spores and moulds in meat packing, for the prevention of moisture absorption in toasted cereals and in many other ways.

In the ceramic industries it is being used to prevent warping, cracking, shrinkage, etc., and in the drying of plaster boards, woods, tiles, brick and all kinds of building materials and composition for preventing warping, cracking, casehardening, etc.

In the munitions industries it prevents static electricity, explosion hazards, etc., and is very necessary to the making of fuses and other timing arrangements where the rate of burning must be regulated to the thousandth of a second.

In wood working it has a multitude of applications but in one particular has come into recent prominence



Air Conditioning Guards the Health and Comfort of the Passengers Aboard the S. S. Leviathan. A View from the Palm Foyer

in the drying and seasoning of wood for airplane propellers and fuselage and for the control of conditions surrounding manufacture and storage of wood and fiber parts which must fit without uneven shrinkage or warpage after months of storage.

A great deal more might be written about the industrial development of air conditioning, but we shall stop here to show more of what influence this has had upon the general subject of air conditioning for comfort and health.

While all of this has been going on for the conditioning of air for processes another class of commercial leaders has been operating on the human side.

We refer here to the theater and amusement house owners, who, seeing also a seasonal dropping off in their business on account of unfavorable weather conditions, started out to correct this by correcting their indoor weather. At the same time many of the manufacturers referred to above came to appreciate the commercial advantages of proper air conditions for their workers. We all know what the results of these two incentives are for most of our theaters. arenas, convention halls, department stores, factories and some office buildings are equipped with apparatus for properly conditioning the air for the health and comfort of the occupants.

Standards for Comfort and Health

Paralleling all of this there has been going on at the American Society of Heating and Ventilating Engineers Research Laboratories in Pittsburgh (in conjunction with the U. S. Bureau of Mines and the U. S. Public Health Service) a series of tests for the past ten years in order to determine the proper standards for indoor atmospheres based upon the comfort and health of the occupants.

These standards have now been established, proved and generally accepted. They have not as yet been put into general use so far as schools, hospitals and other public buildings are concerned, for the simple reason, as we have stated, that the responsibility for the air conditions in these classes of buildings rests with laymen who have not been closely associated with either the scientific, industrial or commercial progress, as outlined above, and are not, therefore, familiar with what is going on.

There is fast developing in this country a controlled air mindedness among the people and my own personal experience and the experience of some others with whom I associate is that those who are responsible for the air conditions in our public buildings are coming more and more to request real controlled air instead of any makeshifts.

Steam, Water and Air Lines in Railroad Yards and Terminals

STEAM, water and air lines for railroad yards and terminals should be discussed under two general groups, namely, power plants and yard distribution. The power plants referred to here are small plants supplying yards, shops and terminals with electricity, steam, water and compressed air. The piping for power plants can be standardized, as the general layout of the piping for any power plant is practically the same regardless of the location, but the piping for yard lines depends upon local conditions and service requirements. This subject will, therefore, be discussed under two general groups, power plants and yards.

The piping in power plants should be so laid out that each of the facilities is grouped together, and should

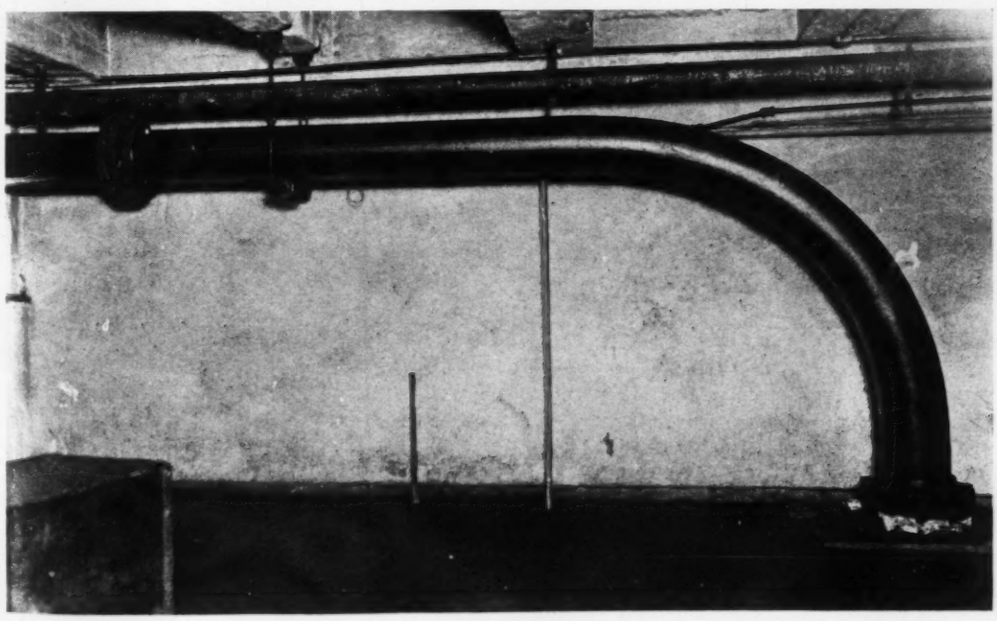


FIG. 1—PHOTOGRAPH OF A 12 INCH PIPE BEND

be so installed that it is accessible for maintenance. Especially is this true of the boiler blow-down lines and feed water lines, which deteriorate faster than other piping. It is necessary to allow for expansion and contraction of steam lines, and this expansion and contraction should be provided for by pipe bends. Fig. 1 shows a 12-inch pipe bend.

Joints for the steam piping in railroad power plants are either of the Vanstone type or welded, the small lines using screwed joints. Flanged couplings are used. The main steam header should be so laid out that in case of trouble, certain sections can be isolated for repairs; especially is this true for plants running twenty-four hours per day during the entire year. In small heating plants, the piping can be simplified.

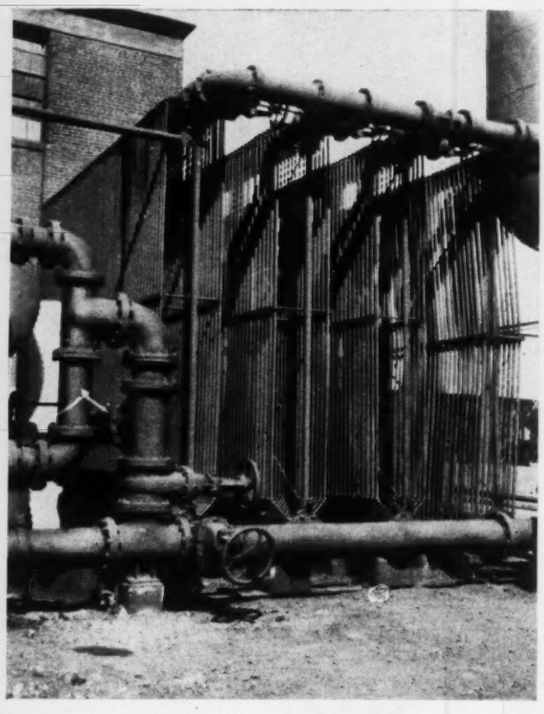


FIG. 2—TYPE OF AFTER COOLER USED BY MANY RAILROADS

Vibration

Vibration in steam lines is usually due to faulty design. Steam lines are usually designed so that the velocity is about 5,000 feet per minute or higher; for steam turbines, 8,000 feet and higher is allowed. Sharp turns or short radius elbows are likely to set up vibration due to sudden change in the direction of flow. If the line is anchored, the trouble is not always taken care of as the cause has not been removed and in time the anchor will become loosened sufficiently to allow piping to vibrate as badly as before causing leaks at joints.

Vibration is often caused by the installation of reciprocating engines close to the distribution header. This is caused by the starting and stopping of the steam due to the operation of the engine valves which tends to pull the pipe in the direction of flow when the valves are closed, and to spring back when the valves are open. Short bends or elbows amplify this vibration and the use of long sweep bends is strongly recommended.

In well designed piping systems, receiver-separators of large volume are nearly always used, placed close to the engines. Where such separators have a capacity of three times the volume of the high pressure cylinder or greater, the piping may be reduced 10 to 15 per cent from the sizes called for by the engine manufacturers, this reduction being made in the piping from the distribution header to the inlet side of the separator.

The action of the steam going through the separator is somewhat as follows; when the valve opens at each stroke of the engine piston, the engine obtains the necessary volume of steam from the separator to force the piston to the end of the stroke. This requires but a fraction of a second in ordinary cases. In this short space of time, enough steam is drawn from the separator to reduce its pressure. The boiler pressure is forcing new steam to the separator through the inlet pipe at a high velocity, and when the valve closes again, due to the reduced pressure, the steam rushes into the separator, restoring the volume and pressure required for the next stroke of the piston. This goes on continuously while the engine is running. The steam from the inlet pipe to the separator flows at an almost constant velocity, cushioning itself against the steam already in the separator, thus causing a steady and rapid flow of steam to the engine and preventing vibration.

Service Piping

Service lines from the main header should be so installed that an isolated section of the header will not shut off the service supply to the yards. Steam piping can and should be installed so that a small number of traps are necessary. If piping is properly drained and laid out, the number of traps can be reduced to a minimum.

Water Piping

The water piping for plants should be isolated so that the supply lines for the plant are accessible and can be inspected readily. These lines are the life of the plant and it is important to see that they are so installed that the engineer in charge can make a quick inspection and locate trouble. A stand-by supply of water should be available for power plants, so that in case of a shut-off of water supply, the plant can run a short time, enabling the operating forces to either close down the plant, or make temporary repairs.

Boiler Feed Water Piping

The boiler feed water line should be in duplicate or laid out in ring header form, and the piping should be of material that will not deteriorate rapidly due to corrosion and pitting. Provisions should be made by installing tees or special fittings so that the piping can be cleaned out and inspected. If there is trouble due to corrosion or pitting, water treating equipment should be installed. Boiler feed water regulators are recommended for most installations. The low cost of this equipment no doubt pays for itself in a short time in the saving of fuel and allows a continuous flow of water in the feed water piping which helps to eliminate corrosion.

Air Compressor Piping

Air compressors and piping for them provide an important service for most railroad yards. Compressed air is used for brake tests, charging train lines and, by some railroads, is used for operating switches, signals, car retarders for "Hump" yard classification and construc-

tion forces on track work. The air intake to the air compressors should be provided with filters which will eliminate dirt and cinders entering the compressor cylinders, thereby resulting in low maintenance. It is also important that the piping for the compressors and services to the yards be so installed as to allow for expansion and contraction. There is a possibility that the service line may heat up considerably if the inter-coolers and after-coolers are not large enough, or if the water is shut off to this equipment which allows the piping from the compressors to become very hot. There is also a possibility of oil catching fire in the compressors, and this fire will follow along the inside of the piping which is likely to heat the piping up to 700 or 800 deg. fahr. or higher.

The discharge piping from each compressor should be equipped with a fusible plug to protect machines from overheating due to a shut-off of the cooling water to the equipment or other causes which might cause overheating. The fusible plug should operate at approximately 500 deg. fahr.

The installation of inter-coolers and after-coolers should receive careful consideration, and receivers installed near compressors with a minimum number of fittings to reduce excessive noise caused by valve slap in the compressors. Where compressed air is used for operating switches, car retarder movements, signals, etc., especially in cold climates, the presence of water is very objectionable due to freezing and making these most important factors inoperative, and to this end, special care should be given to the proper cooling of air after leaving compressor to completely condense all moisture after compression. Some railroads advocate the use of one square foot of air after-cooler surface for each cubic foot of compressor capacity.

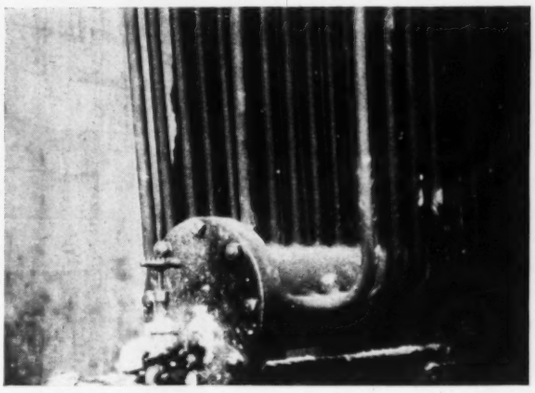


FIG. 3—ANOTHER VIEW OF AN AFTER COOLER

Figs. 2 and 3 show two views of a type of after-cooler used by a good many railroads. This type is air cooled and consists of a header top and bottom connected with ¾-inch pipes bent at the center to allow for expansion. Note that the photographs show two types of after-cooler. Fig. 2 shows an after-cooler made up with fittings, unions and small expansion joints on center pipe. Fig. 3 is a completely welded after-cooler.

Each air compressor should be equipped with a safety valve set a few pounds above the working pressure, and where more than one compressor is connected to a main header, it is advisable to have an additional safety valve in the header.

Identification of Piping

All the piping in the boiler plant should be well marked, and the different services should be painted in colors so as to identify them. The method of only marking the flanges or fittings is not good practice, especially where welded joints are used. It may mean that the operating man would have to follow a line for a considerable distance to identify it. Piping should be so installed that sections can be removed readily for inspection at different times. This applies especially to feed water piping for boilers.

Valves

The valves for the different facilities in power plants should be given careful study. The large valves for steam lines should be outside screw and yoke type with rising stem, and important valves on the boiler feed water line should be of the same type. When this type of valve is used, the operating force can tell at a glance whether the valve is open or closed. Ladders and walkways, where necessary, should be installed so that the valves can be operated with safety by persons in charge of this work. The valve should, therefore, be installed so as to be easily accessible and keep the cost of these ladders and walkways at a minimum.

Steel valves are used for steam lines, even with low pressure, with the trim for the valves of monel metal or similar metal which valve manufacturers are using today. Bronze trim valves are used for low pressures and temperatures. Effect of wire drawing and of feed water treatment should be given due consideration in the selection of valves.

Superheated Steam

Superheaters are being used and recommended for boilers supplying yards with steam. The amount of superheat depends on the condition of the yard piping and general layout, but there should be at least 20 deg. fahr. of superheat leaving the power plant. Superheated steam will keep the steam mains dry and will give more efficient service due to less loss in pressure and condensate in the steam lines. Smaller traps can be installed on superheated lines.

Testing Pipe Lines

All pipe lines, should be tested after installation at a hydraulic pressure one and one-half times the working pressure. Steam pipes should have steam pressure applied, and then tested.

Steam Traps

Traps for steam lines in power plants are an important item, and steam lines, as stated before, should be laid out so as to eliminate as much as possible the installation of traps. If steam mains are properly drained and pockets are eliminated, very few traps are required. It is hard for engineers to agree on what type of trap should be used. In the power plants, the float trap is used as well as certain types of bucket traps. Thermostatic traps are sometimes used, but traps which are required to handle a large amount of condensate are usually either of the float or bucket type. These traps should be substantially constructed and the valve mechanism constructed of material that will stand wire drawing.

This information was abstracted from a paper presented at the 1929 meeting of the International Railway Fuel Association.

Measurement of Flow of Liquids by the Co-ordinate Method

By Prof. F. W. Greve

THE tests conducted recently at the laboratories at Purdue University on the measurement of the flow of liquids in pipes by the co-ordinate method were described in the September HEATING, PIPING AND AIR CONDITIONING. Partial results were also published in that number, and the present tables are submitted to complete the data obtained. These tables should prove useful in many instances, as the co-ordinate method is simple, inexpensive, and has many applications in field tests where the maximum permissible error is ten per cent.

The co-ordinates of the stream issuing from the pipe are meas-

TABLE 9. DATA OF TESTS FOR 2-INCH PIPE

Test	Time Min.	Discharge c.f.s.	y in feet x=0	x= .5 ft.	x= 1 ft.	x= 1.5 ft.	x= 2 ft.	Depth ft. x=0	K= Depth / Diam. x=0
1	5	.00936	.131	.....	.....	.....	.....	.0430	.248
2	5	.00939	.130	.....	.....	.....	.....	.0433	.250
3	5	.0113	.124	.....	.....	.....	.....	.0498	.287
4	5	.0115	.124	.....	.....	.....	.....	.0495	.285
5	5	.0135	.119	.....	.....	.....	.....	.0547	.315
6	5	.0136	.119	.....	.....	.....	.....	.0545	.314
7	5	.0163	.113	.....	.....	.....	.....	.0610	.352
8	5	.0163	.112	.....	.....	.....	.....	.0612	.353
9	4	0186	.108	.....	.....	.....	.....	.0658	.379
10	4	.0185	.108	.....	.....	.....	.....	.0655	.378
11	3	.0309	.0864	.....	.....	.....	.....	.0871	.502
12	3	.0338	.0768	.....	.....	.....	.....	.0967	.557
13	3	.0372	.0656	.....	.....	.....	.....	.108	.623
14	3	.0371	.0659	.....	.....	.....	.....	.108	.623
15	3	.0411	.0556	.....	.....	.....	.....	.119	.686
16	3	.0408	.0557	.....	.....	.....	.....	.118	.680
17	3	.0225	.0999	.....	.....	.....	.....	.0736	.424
18	3	.0226	.0994	.....	.....	.....	.....	.0741	.427
19	12	.0109	.123	.....	.....	.....	.....	.0487	.281
20	11	.0115	.121	.....	.....	.....	.....	.0506	.292
21	10	.0126	.116	.....	.....	.....	.....	.0550	.317
22	10	.0126	.116	.....	.....	.....	.....	.0550	.317
23	10	.0177	.106	.....	.....	.....	.....	.0647	.373
24	10	.0189	.104	.....	.....	.....	.....	.0671	.387
25	10	.0210	.0994	.....	.....	.....	.....	.0720	.415
26	10	.0300	.0872	.....	.....	.....	.....	.0842	.485
27	10	.0358	.0711	.....	.....	.....	.....	.100	.577
28	11	.0387	.0609	.....	.....	.....	.....	.111	.640
29	5	.0420	.....	.....	.....	.....	.....	.....	.....
30	5	.0421	.....	.....	.....	.....	.....	.....	.....
31	2.5	.0527	.....	.....	.....	.....	.....	.....	.....
32	2	.0530	.....	.....	.....	.....	.....	.....	.....
33	3	.0605	.....	.552	.....	.....	.....	.....	.....
34	3	.0605	.....	.554	.....	.....	.....	.....	.....
35	2	.0745	.....	.427	.....	.....	.....	.....	.....
36	2	.0737	.....	.428	.....	.....	.....	.....	.....
37	2	.0993	.....	.260	.....	.....	.....	.....	.....
38	2	.0991	.....	.260	.....	.....	.....	.....	.....
39	2	.117	.....	.187	.....	.....	.....	.....	.....
40	2	.117	.....	.189	.....	.....	.....	.....	.....
41	4	.112	.....	.209	.....	.....	.....	.....	.....
42	4	.109	.....	.221	.....	.....	.....	.....	.....
43	4	.105	.....	.236	.....	.....	.....	.....	.....
44	4	.0993	.....	.263	.....	.....	.....	.....	.....
45	4	.0940	.....	.296	.....	.....	.....	.....	.....
46	4	.0893	.....	.320	.....	.....	.....	.....	.....
47	4	.0819	.....	.366	.....	.....	.....	.....	.....
48	4	.0762	.....	.400	.....	.....	.....	.....	.....
49	4	.0702	.....	.452	.....	.....	.....	.....	.....
50	5	.0663	.....	.498	.....	.....	.....	.....	.....
51	4	.0615	.....	.558	.....	.....	.....	.....	.....
52	4	.0585	.....	.577	.....	.....	.....	.....	.....

TABLE 9—Concluded

Test	Time Min.	Discharge c.f.s.	y in feet x=0	x= .5 ft.	x= 1 ft.	x= 1.5 ft.	x= 2 ft.	Depth ft. x=0	K= Depth / Diam. x=0
53	3	.124	.....	.171	.584	.....	.....	.....	.....
54	3	.124	.....	.169	.587	.....	.....	.....	.....
55	3	.132	.....	.152	.513	.....	.....	.....	.....
56	3	.133	.....	.152	.516	.....	.....	.....	.....
57	3	.140	.....	.136	.482	.....	.....	.....	.....
58	3	.140	.....	.129	.465	.....	.....	.....	.....
59	3	.161	.....	.100	.347	.....	.....	.....	.....
60	3	.161	.....	.101	.353	.....	.....	.....	.....
61	3	.175	.....	.0934	.306	.....	.....	.....	.....
62	4	.171	.....	.0992	.320	.....	.....	.....	.....
63	5	.167	.....	.0999	.332	.....	.....	.....	.....
64	4	.162	.....	.105	.350	.....	.....	.....	.....
65	4	.157	.....	.110	.371	.....	.....	.....	.....
66	4	.152	.....	.120	.395	.....	.....	.....	.....
67	4	.152	.....	.118	.396	.....	.....	.....	.....
68	4	.149	.....	.121	.410	.....	.....	.....	.....
69	5	.147	.....	.126	.431	.....	.....	.....	.....
70	5	.140	.....	.139	.457	.....	.....	.....	.....
71	4	.134	.....	.149	.491	.....	.....	.....	.....
72	4	.130	.....	.160	.533	.....	.....	.....	.....
73	4	.126	.....	.167	.565	.....	.....	.....	.....
74	4	.122	.....	.181	.560	.....	.....	.....	.....
75	4	.118	.....	.189	.633	.....	.....	.....	.....
76	5	.235	.....	.0673	.177	.367	.....	.....	.....
77	4	.231	.....	.0583	.185	.377	.....	.....	.....
78	5	.227	.....	.0594	.187	.390	.....	.....	.....
79	5	.223	.....	.0622	.201	.409	.....	.....	.....
80	5	.217	.....	.0643	.208	.429	.....	.....	.....
81	4	.211	.....	.0669	.224	.456	.....	.....	.....
82	5	.205	.....	.0700	.233	.478	.....	.....	.....
83	5	.202	.....	.0721	.241	.488	.....	.....	.....
84	5	.197	.....	.0747	.248	.506	.....	.....	.....
85	5	.195	.....	.0768	.254	.522	.....	.....	.....
86	6	.183	.....	.0860	.283	.589	.....	.....	.....
87	6	.181	.....	.0893	.289	.597	.....	.....	.....
88	8	.176	.....	.0908	.299	.623	.....	.....	.....
89	8	.348	.....	.0260	.0794	.171	.292	.....	.....
90	8	.358	.....	.0247	.0755	.161	.273	.....	.....
91	8	.361	.....	.0260	.0755	.159	.275	.....	.....
92	7	.356	.....	.0260	.0768	.164	.277	.....	.....
93	6	.355	.....	.0273	.0781	.167	.281	.....	.....
94	7	.341	.....	.0286	.0846	.176	.306	.....	.....
95	7	.334	.....	.0304	.0895	.188	.322	.....	.....
96	6	.329	.....	.0322	.0919	.193	.337	.....	.....
97	7	.276	.....	.0403	.128	.268	.454	.....	.....
98	6	.272	.....	.0424	.130	.277	.466	.....	.....
99	7	.265	.....	.0450	.138	.286	.490	.....	.....
100	7	.257	.....	.0484	.149	.309	.520	.....	.....
101	6	.248	.....	.0524	.159	.332	.558	.....	.....
102	6	.241	.....	.0555	.171	.351	.590	.....	.....
103	6	.286	.....	.0382	.119	.248	.417	.....	.....
104	5	.297	.....	.0341	.109	.225	.382	.....	.....
105	6	.305	.....	.0296	.0997	.212	.360	.....	.....
106	5	.308	.....	.0304	.0994	.207	.352	.....	.....
107	6	.316	.....	.0299	.0932	.199	.335	.....	.....

TABLE 10. DATA OF TESTS FOR 3-INCH PIPE

Test	Time Min.	Discharge c.f.s.	y in feet x=0	x= .5 ft.	x= 1 ft.	x= 1.5 ft.	x= 2 ft.	Depth ft x=0	K= Depth / Diam. x=0
1	10	.0162	.201	.....	.....	.....	.....	.0541	.212
2	10	.0162	.201	.....	.....	.....	.....	.0541	.212
3	10	.0278	.181	.....	.....	.....	.....	.0732	.288
4	10	.0268	.182	.....	.....	.....	.....	.0731	.287
5	8	.0490	.154	.....	.....	.....	.....	.101	.397
6	8	.0495	.154	.....	.....	.....	.....	.101	.397
7	6	.0778	.127	.....	.....	.....	.....	.127	.499
8	6	.0776	.127	.....	.....	.....	.....	.127	.499
9	10	.0140	.205	.....	.....	.....	.....	.0495	.194
10	10	.0142	.205	.....	.....	.....	.....	.0500	.196
11	10	.107	.107	.....	.....	.....	.....	.147	.578
12	10	.0835	.118	.....	.....	.....	.....	.137	.538
13	15	.0745	.139	.....	.....	.....	.....	.115	.452
14	10	.0551	.147	.....	.....	.....	.....	.107	.420
15	15	.0399	.164	.....	.....	.....	.....	.0904	.354
16	20	.0234	.189	.....	.....	.....	.....	.066	.299
17	20	.0306	.177	.....	.....	.....	.....	.0774	.304
18	20	.0311	.176	.....	.....	.....	.....	.0786	.309
19	10	.0336	.171	.....	.....	.....	.....	.0831	.326
20	10	.0451	.158	.....	.....	.....	.....	.0967	.380
21	10	.0396	.163	.....	.....	.....	.....	.0911	.358
22	10	.0439	.160	.....	.....	.....	.....	.0947	.372
23	10	.0643	.138	.....	.....	.....	.....	.116	.456
24	10	.0491	.152	.....	.....	.....	.....	.103	.405
25	10	.146	.0461	.....	.....	.....	.....	.208	.817
26	10	.127	.0717	.....	.....	.....	.....	.183	.719
27	10	.144	.0476	.....	.....	.....	.....	.207	.813
28	10	.114	.0845	.....	.....	.....	.....	.170	.668
29	6	.0631	.142	.659	.....	.....	.....	.113	.444
30	6	.0622	.142	.657	.....	.....	.....	.113	.444
31	6	.0956	.111	.558	.....	.....	.....	.144	.566
32	6	.0956	.110	.567	.....	.....	.....	.145	.570
33	8	.144	.0325	.492	.....	.....	.....	.232	.912
34	8	.122	.0669	.532	.....	.....	.....	.188	.738
35	4	.141	.....	.501	.....	.....	.....	.....	.....
36	4	.141	.....	.501	.....	.....	.....	.....	.....
37	3	.147	.....	.483	.....	.....	.....	.....	.....
38	3	.147	.....	.486	.....	.....	.....	.....	.....
39	4	.247	.....	.218	.....	.....	.....	.....	.....
40	4	.251	.....	.217	.....	.....	.....	.....	.....
41	3	.206	.....	.312	.....	.....	.....	.....	.....
42	3	.207	.....	.310	.....	.....	.....	.....	.....
43	3	.180	.....	.391	.....	.....	.....	.....	.....
44	3	.179	.....	.390	.....	.....	.....	.....	.....
45	5	.514	.....	.0464	.....	.....	.....	.....	.....
46	5	.555	.....	.0359	.....	.....	.....	.....	.....
47	5	.213	.....	.296	.....	.....	.....	.....	.....
48	5	.202	.....	.321	.....	.....	.....	.....	.....
49	5	.188	.....	.358	.....	.....	.....	.....	.....
50	5	.175	.....	.402	.....	.....	.....	.....	.....
51	5	.164	.....	.438	.....	.....	.....	.....	.....
52	5	.206	.....	.308	.....	.....	.....	.....	.....
53	5	.270	.....	.192	.....	.....	.....	.....	.....
54	5	.314	.....	.147	.....	.....	.....	.....	.....
55	5	.345	.....	.126	.....	.....	.....	.....	.....
56	5	.359	.....	.120	.....	.....	.....	.....	.....

ured in feet and are tabulated as x and y. The tests cover 2, 3, 4, 5 and 6-in. pipes with values of x, the horizontal co-ordinate, at zero, 0.5, 1.0, 1.5, and 2.0 ft. *K*, as tabulated here, represents the ratio of the depth to the diameter at the outlet of the pipe.

In using this method, the pipe must be horizontal. A machinists' combination square and a machined steel rod fastened to the top of the pipe in a position parallel to the axis were used to measure the co-ordinates of a selected point in the upper surface of the issuing stream. The rod was slotted for the insertion of the scale and was fastened to the pipe by adjustable clamps.

TABLE 10—Concluded

Test	Time Min.	Discharge c.f.s.	y in feet x=0	x= .5 ft.	x= 1 ft.	x= 1.5 ft.	x= 2 ft.	Depth ft. x=0	K = Depth / Diam. x=0
57	5	.377	.....	.101	.....	.....	.....	.....	.....
58	5	.409	.....	.0885	.....	.....	.....	.....	.....
59	4	.688	.....	.0182	.0802	.....	.....	.....	.....
60	4	.687	.....	.0218	.0823	.....	.....	.....	.....
61	5	.330	.....	.131	.411	.....	.....	.....	.....
62	4	.332	.....	.130	.411	.....	.....	.....	.....
63	4	.306	.....	.149	.474	.....	.....	.....	.....
64	5	.310	.....	.148	.467	.....	.....	.....	.....
65	5	.385	.....	.103	.316	.....	.....	.....	.....
66	5	.375	.....	.112	.332	.....	.....	.....	.....
67	5	.373	.....	.109	.334	.....	.....	.....	.....
68	5	.358	.....	.118	.362	.....	.....	.....	.....
69	5	.321	.....	.137	.423	.....	.....	.....	.....
70	5	.306	.....	.151	.477	.....	.....	.....	.....
71	5	.287	.....	.167	.527	.....	.....	.....	.....
72	6	.248	.....	.227	.701	.....	.....	.....	.....
73	6	.398	.....	.0867	.286	.584	.....	.....	.....
74	6	.399	.....	.0856	.289	.602	.....	.....	.....
75	11	.390	.....	.0945	.308	.623	.....	.....	.....
76	10	.423	.....	.0773	.245	.503	.....	.....	.....
77	10	.452	.....	.0685	.225	.470	.....	.....	.....
78	5	.479	.....	.....	.....	.410	.....	.....	.....
79	5	.518	.....	.....	.170	.357	.....	.....	.....
80	5	.555	.....	.....	.145	.305	.....	.....	.....
81	3	.596	.....	.....	.120	.257	.....	.....	.....
82	10	.632	.....	.0247	.102	.221	.....	.....	.....
83	5	.546	.....	.0423	.148	.317	.....	.....	.....
84	10	.534	.....	.0464	.158	.320	.....	.....	.....
85	8	.526	.....	.0477	.167	.334	.....	.....	.....
86	9	.509	.....	.0505	.175	.357	.....	.....	.....
87	8	.504	.....	.0524	.179	.367	.....	.....	.....
88	8	.499	.....	.0557	.182	.380	.....	.....	.....
89	7	.498	.....	.0552	.181	.379	.....	.....	.....
90	8	.506	.....	.0525	.178	.369	.....	.....	.....
91	9	.493	.....	.0550	.186	.387	.....	.....	.....
92	7	.487	.....	.0576	.194	.396	.....	.....	.....
93	7	.484	.....	.0596	.192	.407	.....	.....	.....
94	6	.475	.....	.0615	.205	.423	.....	.....	.....
95	7	.467	.....	.0672	.216	.432	.....	.....	.....
96	7	.455	.....	.0708	.227	.464	.....	.....	.....
97	7	.449	.....	.0737	.234	.478	.....	.....	.....
98	7	.452	.....	.0734	.235	.474	.....	.....	.....
99	8	.415	.....	.0864	.272	.551	.....	.....	.....
100	7	.400	.....	.0958	.296	.600	.....	.....	.....
101	5	.583	.....	.0338	.125	.267	.....	.....	.....
102	11	.659	.....	.0242	.0911	.199	.361	.....	.....
103	8	.667	.....	.0224	.0916	.201	.366	.....	.....
104	7	.617	.....	.0317	.118	.249	.439	.....	.....
105	7	.617	.....	.0325	.115	.242	.435	.....	.....
106	9	.545	.....	.0419	.148	.315	.550	.....	.....
107	9	.545	.....	.0398	.147	.316	.553	.....	.....
108	10	.489	.....	.0555	.190	.392	.681	.....	.....
109	9	.493	.....	.0550	.185	.391	.670	.....	.....
110	4	.702	.....	.....	.....	.179	.323	.....	.....
111	4	.711	.....	.....	.....	.181	.327	.....	.....

TABLE 11. DATA OF TESTS FOR 4-INCH PIPE

Test	Time Min.	Discharge c.f.s.	y in feet x=0	x= .5 ft.	x= 1 ft.	x= 1.5 ft.	x= 2 ft.	Depth ft. x=0	K = Depth / Diam. x=0
1	10	.0258	.283	.....	.....	.....	.....	.0599	.175
2	10	.0251	.283	.....	.....	.....	.....	.0599	.175
3	10	.0370	.267	.....	.....	.....	.....	.0755	.221
4	8	.0985	.212	.....	.....	.....	.....	.131	.383
5	8	.100	.212	.....	.....	.....	.....	.131	.383
6	6	.137	.188	.....	.....	.....	.....	.155	.453
7	6	.137	.188	.....	.....	.....	.....	.155	.453
8	10	.199	.155	.....	.....	.....	.....	.187	.546
9	10	.198	.157	.....	.....	.....	.....	.186	.543
10	7	.237	.115	.....	.....	.....	.....	.228	.666
11	10	.0698	.234	.....	.....	.....	.....	.108	.315
12	10	.0702	.234	.....	.....	.....	.....	.108	.315
13	15	.0298	.275	.....	.....	.....	.....	.0677	.198
14	15	.0303	.275	.....	.....	.....	.....	.0677	.198
15	15	.0303	.275	.....	.....	.....	.....	.0677	.198
16	5	.146	.179	.....	.....	.....	.....	.165	.482
17	5	.129	.189	.....	.....	.....	.....	.154	.450
18	5	.161	.171	.....	.....	.....	.....	.172	.502
19	5	.178	.162	.....	.....	.....	.....	.181	.529
20	4	.251	.125	.....	.....	.....	.....	.219	.639
21	4	.272	.0923	.....	.....	.....	.....	.251	.733
22	4	.293	.0891	.....	.....	.....	.....	.254	.742
23	4	.355	.0758	.....	.....	.....	.....	.268	.782
24	3	.249	.103	.....	.....	.....	.....	.241	.704
25	3	.241	.111	.....	.....	.....	.....	.233	.680
26	3	.233	.117	.....	.....	.....	.....	.226	.660
27	3	.217	.134	.....	.....	.....	.....	.210	.613
28	3	.203	.150	.....	.....	.....	.....	.194	.566
29	5	.236	.115	.499	.....	.....	.....	.227	.663
30	5	.297	.0880	.437	.....	.....	.....	.254	.742
31	4	.294	.0846	.438	.....	.....	.....	.258	.753
32	4	.398	.0371	.332	.....	.....	.....	.306	.894
33	4	.388	.0522	.338	.....	.....	.....	.291	.850
34	4	.381	.0485	.342	.....	.....	.....	.295	.861
35	4	.371	.0527	.367	.....	.....	.....	.291	.850
36	4	.369	.0613	.365	.....	.....	.....	.282	.824
37	3	.360	.0527	.371	.....	.....	.....	.291	.850
38	4	.349	.0639	.383	.....	.....	.....	.280	.818
39	4	.334	.0665	.406	.....	.....	.....	.277	.809
40	3	.322	.0704	.420	.....	.....	.....	.273	.797
41	4	.311	.0758	.435	.....	.....	.....	.268	.782
42	4	.290	.0779	.461	.....	.....	.....	.266	.777
43	4	.268	.0928	.481	.....	.....	.....	.251	.733
44	3	.443	.....	.268	.....	.....	.....	.....	.....
45	3	.439	.....	.270	.....	.....	.....	.....	.....
46	3	.371	.....	.337	.....	.....	.....	.....	.....
47	3	.361	.....	.441	.....	.....	.....	.....	.....
48	4	.591	.....	.153	.....	.....	.....	.....	.....
49	3	.587	.....	.151	.....	.....	.....	.....	.....
50	3	.579	.....	.160	.....	.....	.....	.....	.....
51	3	.572	.....	.162	.....	.....	.....	.....	.....
52	3	.565	.....	.163	.....	.....	.....	.....	.....
53	3	.561	.....	.167	.....	.....	.....	.....	.....
54	3	.552	.....	.173	.....	.....	.....	.....	.....
55	3	.553	.....	.173	.....	.....	.....	.....	.....

TABLE 11—Continued

Test	Time Min.	Discharge c.f.s.	y in feet x=0	x= .5 ft.	x= 1 ft.	x= 1.5 ft.	x= 2 ft.	Depth ft. x=0	K = Depth / Diam. x=0
56	2	.549	.....	.179	.....	.....	.....	.....	.....
57	2.5	.544	.....	.180	.....	.....	.....	.....	.....
58	2.5	.538	.....	.184	.....	.....	.....	.....	.....
59	2	.527	.....	.189	.....	.....	.....	.....	.....
60	2	.496	.....	.214	.....	.....	.....	.....	.....
61	2	.491	.....	.223	.....	.....	.....	.....	.....
62	2	.482	.....	.230	.....	.....	.....	.....	.....
63	2	.474	.....	.239	.....	.....	.....	.....	.....
64	2.5	.466	.....	.245	.....	.....	.....	.....	.....
65	2.5	.459	.....	.257	.....	.....	.....	.....	.....
66	2.5	.452	.....	.263	.....	.....	.....	.....	.....
67	2.5	.443	.....	.270	.....	.....	.....	.....	.....
68	2.5	.433	.....	.286	.....	.....	.....	.....	.....
69	2.5	.424	.....	.300	.....	.....	.....	.....	.....
70	2.5	.419	.....	.301	.....	.....	.....	.....	.....
71	2.5	.410	.....	.311	.....	.....	.....	.....	.....
72	2.5	.413	.....	.309	.....	.....	.....	.....	.....
73	2.5	.401	.....	.313	.....	.....	.....	.....	.....
74	2.5	.393	.....	.331	.....	.....	.....	.....	.....
75	2	.384	.....	.341	.....	.....	.....	.....	.....
76	2.5	.366	.....	.370	.....	.....	.....	.....	.....
77	3	.703	.....	.108	.330	.....	.....	.....	.....
78	3	.704	.....	.106	.331	.....	.....	.....	.....
79	3	.606	.....	.154	.437	.....	.....	.....	.....
80	4	.609	.....	.153	.436	.....	.....	.....	.....
81	3	.532	.....	.199	.568	.....	.....	.....	.....
82	4	.531	.....	.203	.551	.....	.....	.....	.....
83	5	.811	.....	.0743	.238	.....	.....	.....	.....
84	5	.797	.....	.0764	.248	.....	.....	.....	.....
85	6	.896	.....	.0582	.191	.....	.....	.....	.....
86	6	.872	.....	.0636	.205	.....	.....	.....	.....
87	6	.832	.....	.0706	.232	.....	.....	.....	.....
88	6	.826	.....	.0732	.236	.....	.....	.....	.....
89	6	.819	.....	.0751	.243	.....	.....	.....	.....
90	5	.814	.....	.0761	.240	.....	.....	.....	.....
91	5	.804	.....	.0782	.248	.....	.....	.....	.....
92	4	.790	.....	.0810	.255	.....	.....	.....	.....
93	4	.770	.....	.0844	.271	.....	.....	.....	.....
94	4	.747	.....	.0896	.292	.....	.....	.....	.....
95	4	.709	.....	.101	.321	.....	.....	.....	.....
96	4	.669	.....	.114	.366	.....	.....	.....	.....
97	4	.653	.....	.120	.378	.....	.....	.....	.....
98	4	.637	.....	.127	.391	.....	.....	.....	.....
99	4	.632	.....	.131	.408	.....	.....	.....	.....
100	4	.623	.....	.136	.411	.....	.....	.....	.....
101	5	.616	.....	.140	.422	.....	.....	.....	.....
102	5	.603	.....	.148	.444	.....	.....	.....	.....
103	5	.599	.....	.149	.450	.....	.....	.....	.....
104	3	1.09	.....	.0289	.116	.258	.....	.....	.....
105	3	1.10	.....	.0286	.113	.251	.....	.....	.....
106	4	.999	.....	.0419	148	.320	.....	.....	.....
107	3	.995	.....	.0414	.149	.320	.....	.....	.....
108	3	.963	.....	.0485	.161	.348	.....	.....	.....
109	3	.963	.....	.0472	.159	.351	.....	.....	.....
110	3	.937	.....	.0534	.171	.367	.....	.....	.....

(*Continued on following page*)

Measurement of Flow of Liquids by the Co-ordinate Method

x and y Are the Co-ordinates of the Surface of the Stream Issuing from the Pipe. Discharge Is Tabulated in Cubic Feet Per Second. K Represents the Ratio of Depth to Diameter at the Outlet of the Pipe. The Complete Set of Tests Cover 2, 3, 4, 5, and 6-in. Pipes with Values of x, the Horizontal Co-ordinate, at Zero, 0.5, 1.0, 1.5, and 2.0 ft.

Table 11—Concluded

Test	Time Min.	Discharge c.f.s.	y in feet x=0	x= .5 ft.	x= 1 ft.	x= 1.5 ft.	x= 2 ft.	Depth ft. x=0	K = Depth / Diam. x=0
111	3	.937	.....	.0518	.175	.378	.....	.....	.....
112	3	.812	.....	.0729	.235	.496	.....	.....	.....
113	7	1.07	.....	.0308	.118	.277	.....	.....	.....
114	7	1.06	.....	.0293	.124	.275	.....	.....	.....
115	6	1.01	.....	.0379	.145	.316	.....	.....	.....
116	7	1.00	.....	.0433	.151	.320	.....	.....	.....
117	6	.992	.....	.0441	.155	.324	.....	.....	.....
118	7	.989	.....	.0478	.157	.326	.....	.....	.....
119	7	.981	.....	.0478	.159	.331	.....	.....	.....
120	7	.984	.....	.0462	.160	.331	.....	.....	.....
121	7	.972	.....	.0485	.162	.338	.....	.....	.....
122	7	.958	.....	.0511	.165	.347	.....	.....	.....
123	8	.948	.....	.0530	.174	.354	.....	.....	.....
124	8	.938	.....	.0561	.181	.369	.....	.....	.....
125	8	.926	.....	.0558	.187	.380	.....	.....	.....
126	7	.911	.....	.0597	.186	.391	.....	.....	.....
127	7	.996	.....	.0475	.156	.321	.....	.....	.....
128	6	.936	.....	.0589	.188	.388	.....	.....	.....
129	7	.889	.....	.0610	.198	.413	.....	.....	.....
130	6	.879	.....	.0628	.204	.421	.....	.....	.....
131	7	.869	.....	.0654	.204	.432	.....	.....	.....
132	6	.851	.....	.0686	.219	.444	.....	.....	.....
133	6	.832	.....	.0701	.230	.466	.....	.....	.....
134	6	1.25	.....	.0162	.0792	.189	.334	.....	.....
135	6	1.23	.....	.0196	.0858	.196	.354	.....	.....
136	6	1.22	.....	.0219	.0933	.212	.369	.....	.....
137	6	1.20	.....	.0232	.100	.220	.383	.....	.....
138	6	1.19	.....	.0219	.0983	.224	.381	.....	.....
139	6	1.16	.....	.0276	.109	.235	.416	.....	.....
140	6	1.15	.....	.0284	.109	.241	.430	.....	.....
141	6	1.10	.....	.0295	.121	.267	.457	.....	.....
142	6	1.07	.....	.0292	.118	.269	.460	.....	.....

Table 12. Data of Tests for 5-Inch Pipe

Test	Time Min.	Discharge c.f.s.	y in feet x=0	x= .5 ft.	x= 1 ft.	x= 1.5 ft.	x= 2 ft.	Depth ft. x=0	K = Depth / Diam. x=0
1	7	.0830	.312	.....	.....	.....	.....	.112	.265
2	7	.0830	.313	.....	.....	.....	.....	.110	.260
3	7	.142	.277	.....	.....	.....	.....	.146	.345
4	7	.143	.278	.....	.....	.....	.....	.145	.343
5	3	.483	.123	.....	.....	.....	.....	.300	.709
6	3	.434	.149	.....	.....	.....	.....	.274	.648
7	3	.372	.187	.....	.....	.....	.....	.236	.558
8	3	.315	.209	.....	.....	.....	.....	.214	.506
9	3	.273	.225	.....	.....	.....	.....	.198	.468
10	3	.264	.228	.....	.....	.....	.....	.195	.461

Table 12—Continued

Test	Time Min.	Discharge c.f.s.	y in feet x=0	x= .5 ft.	x= 1 ft.	x= 1.5 ft.	x= 2 ft.	Depth ft. x=0	K = Depth / Diam. x=0
11	3	.312	.208	.....	.....	.....	.....	.215	.504
12	3	.394	.182	.....	.....	.....	.....	.241	.570
13	3	.421	.161	.....	.....	.....	.....	.262	.619
14	3	.451	.148	.....	.....	.....	.....	.275	.650
15	3	.461	.146	.....	.....	.....	.....	.277	.655
16	3	.473	.141	.....	.....	.....	.....	.282	.666
17	3	.484	.136	.....	.....	.....	.....	.287	.678
18	3	.490	.129	.....	.....	.....	.....	.294	.695
19	3	.543	.128	.....	.....	.....	.....	.295	.697
20	3	.543	.123	.....	.....	.....	.....	.300	.709
21	3	.435	.161	.....	.....	.....	.....	.262	.619
22	3	.430	.161	.....	.....	.....	.....	.262	.619
23	7	.368	.182	.....	.....	.....	.....	.241	.569
24	7	.304	.205	.....	.....	.....	.....	.218	.515
25	7	.264	.223	.....	.....	.....	.....	.201	.475
26	5	.170	.263	.621	.....	.....	.....	.160	.378
27	5	.168	.263	.630	.....	.....	.....	.160	.378
28	4	.595	.0799	.386	.....	.....	.....	.343	.810
29	4	.631	.0726	.359	.....	.....	.....	.350	.827
30	4	.638	.0654	.351	.....	.....	.....	.358	.846
31	4	.646	.0607	.340	.....	.....	.....	.362	.856
32	5	.707	.0185	.295	.....	.....	.....	.404	.955
33	5	.693	.0283	.306	.....	.....	.....	.395	.933
34	6	.671	.0375	.326	.....	.....	.....	.385	.910
35	5	.654	.0367	.335	.....	.....	.....	.386	.912
36	3	.636	.0625	.354	.....	.....	.....	.360	.851
37	5	.295	.216	.527	.....	.....	.....	.207	.489
38	5	.369	.188	.474	.....	.....	.....	.235	.555
39	4	.414	.163	.484	.....	.....	.....	.260	.614
40	5	.468	.128	.463	.....	.....	.....	.295	.697
41	4	.476	.123	.453	.....	.....	.....	.300	.709
42	5	.516	.0994	.429	.....	.....	.....	.324	.766
43	4	.602	.0698	.378	.....	.....	.....	.353	.834
44	4	.729	.....	.285	.....	.....	.....	.....	.....
45	3	.735	.....	.287	.....	.....	.....	.....	.....
46	3	.682	.....	.305	.....	.....	.....	.....	.....
47	3	.679	.....	.307	.....	.....	.....	.....	.....
48	3	.628	.....	.332	.....	.....	.....	.....	.....
49	3	.627	.....	.330	.....	.....	.....	.....	.....
50	3	.839	.....	.232	.....	.....	.....	.....	.....
51	3	.661	.....	.325	.....	.....	.....	.....	.....
52	2	.663	.....	.321	.....	.....	.....	.....	.....
53	2	.671	.....	.317	.....	.....	.....	.....	.....
54	2	.649	.....	.332	.....	.....	.....	.....	.....
55	2	.647	.....	.332	.....	.....	.....	.....	.....
56	2	.657	.....	.327	.....	.....	.....	.....	.....
57	2	.659	.....	.328	.....	.....	.....	.....	.....
58	2	.702	.....	.302	.....	.....	.....	.....	.....
59	2	.713	.....	.293	.....	.....	.....	.....	.....
60	2	.713	.....	.292	.....	.....	.....	.....	.....
61	2	.716	.....	.288	.....	.....	.....	.....	.....
62	2	.721	.....	.280	.....	.....	.....	.....	.....
63	2	.739	.....	.274	.....	.....	.....	.....	.....
64	2	.760	.....	.258	.....	.....	.....	.....	.....
65	2	.770	.....	.249	.....	.....	.....	.....	.....

Table 12—Continued

Test	Time Min.	Discharge c.f.s.	y in feet x=0	x= .5 ft.	x= 1 ft.	x= 1.5 ft.	x= 2 ft.	Depth ft. x=0	K = Depth / Diam. x=0
66	2	.791	.....	.234	.....	.....	.....	.....	.....
67	2	.810	.....	.226	.....	.....	.....	.....	.....
68	2	.826	.....	.216	.....	.....	.....	.....	.....
69	2	.840	.....	.208	.....	.....	.....	.....	.....
70	2	.858	.....	.203	.....	.....	.....	.....	.....
71	2	.877	.....	.192	.....	.....	.....	.....	.....
72	2	.894	.....	.185	.....	.....	.....	.....	.....
73	4	.989	.....	.153	.....	.....	.....	.....	.....
74	3	.923	.....	.181	.....	.....	.....	.....	.....
75	3	.834	.....	.227	.587	.....	.....	.....	.....
76	3	.813	.....	.230	.606	.....	.....	.....	.....
77	3	.810	.....	.231	.619	.....	.....	.....	.....
78	3	.842	.....	.207	.580	.....	.....	.....	.....
79	3	.848	.....	.220	.549	.....	.....	.....	.....
80	3	.924	.....	.173	.468	.....	.....	.....	.....
81	3	.928	.....	.173	.498	.....	.....	.....	.....
82	3	1.10	.....	.....	.369	.....	.....	.....	.....
83	3	1.09	.....	.....	.378	.....	.....	.....	.....
84	3	1.31	.....	.0854	.237	.....	.....	.....	.....
85	3	1.32	.....	.0841	.245	.....	.....	.....	.....
86	3	1.26	.....	.0932	.268	.....	.....	.....	.....
87	3	1.27	.....	.0919	.272	.....	.....	.....	.....
88	3	.882	.....	.....	.524	.....	.....	.....	.....
89	3	.880	.....	.227	.539	.....	.....	.....	.....
90	3	.916	.....	.174	.492	.....	.....	.....	.....
91	3	.952	.....	.158	.464	.....	.....	.....	.....
92	3	.970	.....	.155	.447	.....	.....	.....	.....
93	4	.998	.....	.144	.421	.....	.....	.....	.....
94	3	1.01	.....	.140	.409	.....	.....	.....	.....
95	3	1.03	.....	.133	.394	.....	.....	.....	.....
96	3	1.05	.....	.129	.381	.....	.....	.....	.....
97	3	1.07	.....	.123	.364	.....	.....	.....	.....
98	3	1.09	.....	.118	.351	.....	.....	.....	.....
99	3	1.11	.....	.118	.342	.....	.....	.....	.....
100	3	1.13	.....	.113	.325	.....	.....	.....	.....
101	3	1.15	.....	.109	.312	.....	.....	.....	.....
102	3	1.18	.....	.102	.301	.....	.....	.....	.....
103	3	1.19	.....	.101	.294	.....	.....	.....	.....
104	3	1.20	.....	.0997	.303	.....	.....	.....	.....
105	3	1.22	.....	.0945	.287	.....	.....	.....	.....
106	3	1.23	.....	.0937	.283	.539	.....	.....	.....
107	3	1.22	.....	.0942	.277	.540	.....	.....	.....
108	3	1.24	.....	.0960	.278	.533	.....	.....	.....
109	3	1.25	.....	.0934	.273	.532	.....	.....	.....
110	3	1.25	.....	.0942	.273	.522	.....	.....	.....
111	3	1.26	.....	.0914	.265	.515	.....	.....	.....
112	3	1.36	.....	.0768	.231	.453	.....	.....	.....
113	3	1.39	.....	.0713	.222	.440	.....	.....	.....
114	3	1.39	.....	.0729	.219	.428	.....	.....	.....
115	3	1.43	.....	.0736	.217	.423	.....	.....	.....
116	3	1.50	.....	.0667	.188	.386	.....	.....	.....
117	3	1.53	.....	.0646	.195	.366	.....	.....	.....
118	2	1.56	.....	.0617	.185	.356	.....	.....	.....
119	2	1.60	.....	.0599	.175	.340	.....	.....	.....
120	2	1.48	.....	.0656	.193	.382	.....	.....	.....

X AND Y ARE THE CO-ORDINATES OF THE SURFACE OF THE STREAM ISSUING FROM THE PIPE. DISCHARGE IS TABULATED IN CUBIC FEET PER SECOND. K REPRESENTS THE RATIO OF DEPTH TO DIAMETER AT THE OUTLET OF THE PIPE. THE COMPLETE SET OF TESTS COVER 2, 3, 4, 5, AND 6-IN. PIPES WITH VALUES OF X, THE HORIZONTAL CO-ORDINATE, AT ZERO, 0.5, 1.0, 1.5, AND 2.0 FT.

TABLE 12—Concluded

Test	Time Min	Discharge c.f.s.	y in feet x=0	x= .5 ft.	x= 1 ft.	x= 1.5 ft.	x= 2 ft.	Depth ft. x=0	K= Depth / Diam. x=0
121	4	1.45	.....	.0747	.208	.411	.....	.....	.....
122	4	1.40	.....	.0828	.225	.446	.....	.....	.....
123	3	1.40	.....	.0791	.228	.442	.....	.....	.....
124	4	1.45	.....	.0739	.209	.411	.....	.....	.....
125	4	1.48	.....	.0703	.196	.388	.....	.....	.....
126	4	1.52	.....	.0643	.190	.361	.....	.....	.....
127	4	1.57	.....	.0596	.173	.339	.....	.....	.....
128	3	1.75	.....	.....	.122	.263	.438	.....	.....
129	3	1.75	.....	.....	.119	.258	.428	.....	.....
130	3	1.48	.....	.....	.185	.368	.613	.....	.....
131	3	1.48	.....	.....	.179	.369	.619	.....	.....
132	3	1.73	.....	.....	.127	.262	.436	.....	.....
133	3	1.74	.....	.....	.121	.258	.441	.....	.....
134	2	1.67	.....	.0534	.158	.304	.498	.....	.....
135	2	1.70	.....	.0516	.152	.293	.488	.....	.....
136	2	1.71	.....	.0508	.145	.290	.480	.....	.....
137	2	1.72	.....	.0505	.144	.288	.470	.....	.....
138	2	1.73	.....	.0495	.144	.279	.469	.....	.....
139	2	1.75	.....	.0469	.141	.273	.454	.....	.....
140	2	1.78	.....	.0442	.136	.264	.439	.....	.....
141	2	1.81	.....	.0461	.135	.263	.436	.....	.....
142	2	1.83	.....	.0440	.132	.253	.426	.....	.....
143	3	1.84	.....	.0442	.132	.252	.421	.....	.....
144	3	1.87	.....	.0429	.127	.239	.408	.....	.....
145	3	1.90	.....	.0403	.124	.231	.400	.....	.....
146	3	1.94	.....	.0387	.114	.223	.371	.....	.....
147	2	2.21	.....	.0286	.0786	.158	.276	.....	.....
148	2	2.19	.....	.0273	.0851	.161	.282	.....	.....
149	2	2.18	.....	.0291	.0859	.167	.284	.....	.....
150	2	2.15	.....	.0289	.0921	.174	.280	.....	.....
151	2	2.07	.....	.0317	.0963	.184	.306	.....	.....
152	2	2.02	.....	.0335	.105	.194	.318	.....	.....
153	2	1.97	.....	.0382	.110	.208	.344	.....	.....
154	2	1.89	.....	.0419	.122	.230	.368	.....	.....
155	3	1.84	.....	.0439	.128	.242	.400	.....	.....
156	3	1.80	.....	.0466	.133	.255	.414	.....	.....
157	3	1.78	.....	.0485	.134	.271	.442	.....	.....
158	4	1.73	.....	.0508	.144	.278	.451	.....	.....
159	4	1.69	.....	.0544	.148	.291	.471	.....	.....

TABLE 13. DATA OF TESTS FOR 6-INCH PIPE

Test	Time Min.	Discharge c.f.s.	y in feet x=0	x= .5 ft.	x= 1 ft.	x= 1.5 ft.	x= 2 ft.	Depth ft. x=0	K= Depth / Diam. x=0
1	5	.218	.343	.....	.....	.....	.....	.162	.321
2	5	.376	.285	.....	.....	.....	.....	.220	.436
3	5	.492	.241	.....	.....	.....	.....	.263	.522
4	5	.399	.268	.....	.....	.....	.....	.236	.468

TABLE 13—Continued

Test	Time Min.	Discharge c.f.s.	y in feet x=0	x= .5 ft.	x= 1 ft.	x= 1.5 ft.	x= 2 ft.	Depth ft. x=0	K= Depth / Diam. x=0
5	5	.0837	.410	.....	.....	.....	.....	.0941	.187
6	5	.0722	.415	.....	.....	.....	.....	.0891	.177
7	5	.0583	.424	.....	.....	.....	.....	.0807	.160
8	5	.133	.378	.....	.....	.....	.....	.127	.252
9	5	.468	.248	.....	.....	.....	.....	.256	.508
10	5	.326	.295	.....	.....	.....	.....	.209	.414
11	5	.169	.361	.....	.....	.....	.....	.144	.286
12	5	.145	.372	.....	.....	.....	.....	.132	.262
13	5	.135	.378	.....	.....	.....	.....	.127	.252
14	5	.124	.385	.....	.....	.....	.....	.119	.236
15	3	.119	.387	.....	.....	.....	.....	.118	.234
16	3	.113	.389	.....	.....	.....	.....	.115	.228
17	5	.595	.217	.....	.....	.....	.....	.287	.569
18	5	.718	.164	.454	.....	.....	.....	.340	.674
19	3	.726	.153	.462	.....	.....	.....	.351	.696
20	3	.819	.116	.421	.....	.....	.....	.388	.769
21	3	.847	.103	.409	.....	.....	.....	.402	.797
22	3	.942	.0945	.367	.....	.....	.....	.410	.813
23	3	.990	.0776	.346	.....	.....	.....	.427	.847
24	3	1.08	.0609	.304	.....	.....	.....	.443	.879
25	5	.513	.233	.....	.....	.....	.....	.271	.537
26	5	.561	.209	.501	.....	.....	.....	.295	.585
27	5	.600	.183	.495	.....	.....	.....	.321	.637
28	4	.634	.168	.491	.....	.....	.....	.336	.666
29	4	.677	.150	.478	.....	.....	.....	.354	.702
30	4	.693	.147	.466	.....	.....	.....	.357	.708
31	4	.731	.150	.440	.....	.....	.....	.354	.702
32	4	.756	.149	.423	.....	.....	.....	.355	.704
33	4	.789	.138	.410	.....	.....	.....	.366	.726
34	4	.823	.137	.396	.....	.....	.....	.367	.728
35	4	.847	.136	.389	.....	.....	.....	.368	.730
36	4	.881	.129	.376	.....	.....	.....	.375	.744
37	3	.906	.120	.362	.....	.....	.....	.384	.762
38	3	.934	.124	.354	.....	.....	.....	.380	.754
39	3	.956	.120	.345	.....	.....	.....	.384	.762
40	2	.918	.....	.352	.....	.....	.....	.....	.....
41	2	.940	.....	.343	.....	.....	.....	.....	.....
42	2	.953	.....	.324	.....	.....	.....	.....	.....
43	2	1.00	.....	.308	.....	.....	.....	.....	.....
44	2	1.03	.....	.298	.....	.....	.....	.....	.....
45	2	1.07	.....	.270	.....	.....	.....	.....	.....
46	2	1.11	.....	.257	.....	.....	.....	.....	.....
47	5	1.63	.....	.101	.....	.....	.....	.....	.....
48	3	1.81	.....	.0893	.....	.....	.....	.....	.....
49	3	2.22	.....	.0552	.....	.....	.....	.....	.....
50	3	1.88	.....	.0836	.....	.....	.....	.....	.....
51	3	1.53	.....	.143	.....	.....	.....	.....	.....
52	5	.660	.....	.502	.....	.....	.....	.....	.....
53	5	1.62	.....	.111	.327	.....	.....	.....	.....
54	3	2.78	.....	.0281	.101	.....	.....	.....	.....
55	3	2.72	.....	.0325	.106	.....	.....	.....	.....
56	3	2.40	.....	.0448	.152	.....	.....	.....	.....
57	3	1.97	.....	.0719	.222	.....	.....	.....	.....
58	3	1.76	.....	.0935	.296	.....	.....	.....	.....
59	3	1.42	.....	.168	.451	.....	.....	.....	.....

TABLE 13—Continued

Test	Time Min.	Discharge c.f.s.	y in feet x=0	x= 5 ft.	x= 1 ft.	x= 1.5 ft.	x= 2 ft.	Depth ft. x=0	K= Depth / Diam. x=0
60	3	1.43	.....	.165	.473	.....	.....	.....	.....
61	3	1.61	.....	.118	.350	.....	.....	.....	.....
62	5	1.28	.....	.223	.579	.....	.....	.....	.....
63	4	1.15	.....	.240	.657	.....	.....	.....	.....
64	4	1.18	.....	.232	.611	.....	.....	.....	.....
65	4	1.22	.....	.215	.593	.....	.....	.....	.....
66	4	1.25	.....	.202	.556	.....	.....	.....	.....
67	4	1.28	.....	.188	.526	.....	.....	.....	.....
68	4	1.31	.....	.179	.501	.....	.....	.....	.....
69	3	1.34	.....	.169	.492	.....	.....	.....	.....
70	3	1.65	.....	.108	.329	.....	.....	.....	.....
71	2	1.62	.....	.112	.341	.....	.....	.....	.....
72	2	1.59	.....	.119	.356	.....	.....	.....	.....
73	2	1.57	.....	.125	.371	.....	.....	.....	.....
74	3	1.29	.....	.210	.540	.....	.....	.....	.....
75	3	1.35	.....	.187	.498	.....	.....	.....	.....
76	3	1.39	.....	.175	.476	.....	.....	.....	.....
77	3	1.42	.....	.160	.445	.....	.....	.....	.....
78	2	1.46	.....	.153	.428	.....	.....	.....	.....
79	3	1.50	.....	.142	.402	.....	.....	.....	.....
80	3	1.54	.....	.125	.375	.....	.....	.....	.....
81	3	1.73	.....	.0974	.299	.....	.....	.....	.....
82	3	1.75	.....	.0956	.296	.....	.....	.....	.....
83	4	1.87	.....	.0786	.246	.501	.....	.....	.....
84	3	1.77	.....	.0888	.281	.564	.....	.....	.....
85	3	1.81	.....	.0857	.270	.525	.....	.....	.....
86	2	1.85	.....	.0847	.263	.515	.....	.....	.....
87	3	1.87	.....	.0774	.251	.505	.....	.....	.....
88	2	1.92	.....	.0764	.237	.480	.....	.....	.....
89	3	1.95	.....	.0701	.228	.450	.....	.....	.....
90	3	1.98	.....	.0665	.219	.435	.....	.....	.....
91	3	2.03	.....	.0644	.208	.419	.....	.....	.....
92	3	2.07	.....	.0644	.203	.401	.....	.....	.....
93	3	1.99	.....	.0668	.216	.436	.....	.....	.....
94	3	2.01	.....	.0673	.208	.426	.....	.....	.....
95	3	2.11	.....	.0579	.193	.384	.627	.....	.....
96	3	2.16	.....	.0545	187	.370	.600	.....	.....
97	3	2.28	.....	.0472	.163	.327	.540	.....	.....
98	3	2.32	.....	.0464	.152	.320	.511	.....	.....
99	3	2.36	.....	.0438	.147	.305	.498	.....	.....
100	3	2.41	.....	.0422	.139	.289	.493	.....	.....
101	3	2.45	.....	.0409	.140	.276	.472	.....	.....
102	3	2.39	.....	.0425	.142	.293	.492	.....	.....
103	3	2.43	.....	.0409	.134	.272	.465	.....	.....
104	3	2.47	.....	.0391	.127	.268	.448	.....	.....
105	3	2.50	.....	.0391	.128	.260	.445	.....	.....
106	3	2.54	.....	.0373	.123	.256	.426	.....	.....
107	3	2.60	.....	.0354	.120	.239	.406	.....	.....
108	3	2.64	.....	.0341	.113	.238	.390	.....	.....
109	3	2.64	.....	.0331	.110	.233	.392	.....	.....
110	3	2.62	.....	.0347	.114	.251	.403	.....	.....
111	3	2.10	.....	.0608	.199	.388	.649	.....	.....
112	3	2.01	.....	.0576	.192	.379	.622	.....	.....
113	3	2.10	.....	.0563	.174	.362	.590	.....	.....
114	3	2.23	.....	.0540	.169	.335	.571	.....	.....
115	3	2.28	.....	.0522	.166	.321	.555	.....	.....
116	3	2.31	.....	.0480	.155	.312	.537	.....	.....
117	3	2.38	.....	.0435	.151	.301	.511	.....	.....
118	3	2.62	.....	.0325	.115	.241	.407	.....	.....
119	3	2.33	.....	.0466	.156	.315	.534	.....	.....
120	3	2.21	.....	.....	.174	.359	.....	.....	.....
121	3	1.87	.....	.....	.255	.510	.....	.....	.....
122	3	2.79	.....	.....	.....	.203	.....	.....	.....
123	3	2.70	.....	.....	.....	.216	.....	.....	.....
124	3	2.38	.....	.....	.....	.307	.....	.....	.....
125	3	1.80	.....	.....	.....	.550	.....	.....	.....
126	3	2.77	.....	.....	.....	.....	.358	.....	.....
127	3	2.73	.....	.....	.....	.....	.377	.....	.....
128	3	2.36	.....	.....	.....	.....	.513	.....	.....

Radiator Developments

By Malcolm Tomlinson

THE science of heating, with its allied industries, has grown rapidly in the past ten years. This growth has brought about many changes in the design of equipment and also in the proper use of the various heating devices on the market.

Some of the notable changes in the latter respect are the use of the water type of radiator in place of the old single manifold steam radiator, of enclosures for cast iron radiators and of the scientific location of radiators in order to obtain definite results. It is not our purpose to discuss design or use of radiators in this paper, but to show how radiator development has advanced, and then to give some new facts about radiators which will be of interest to the industry.

In 1920 John R. Allen presented, as director of the new A. S. H. V. E. research laboratory, the results of his investigations on the amount of radiant and convected heat emitted from various types of cast iron radiators designed for use with steam. Extended surface or fin radiators, for use in air blast

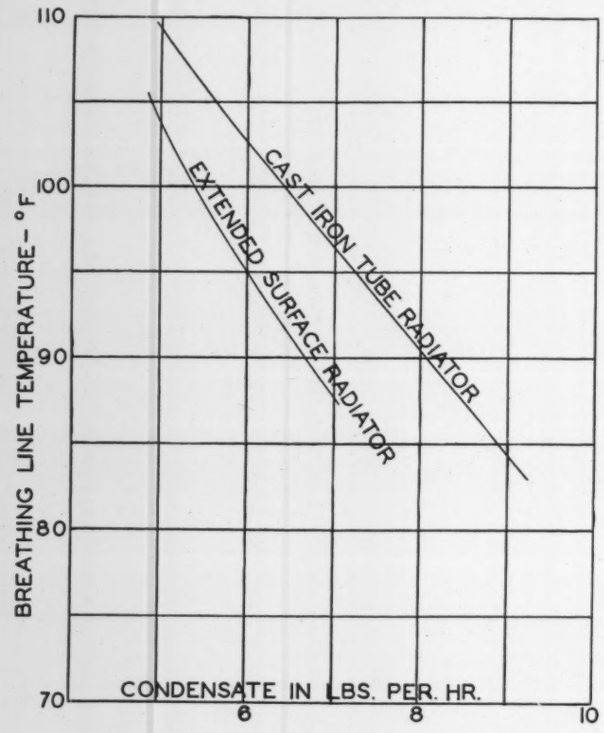


FIG. 1—TEMPERATURE—CONDENSATE CURVES

heating, were developed. Better kinds of enclosures for the gravity type of cast iron radiators came into existence. Furthermore, the industry began to realize the peculiar ways in which convected and radiant heat were transmitted and to make plans to take better advantage of these forms of heat. Previously, all calculations of heat transmission had been of total heat and many grave errors were constantly made.

Progress at first was necessarily slow. No scientific investigations on radiators were again reported until 1926, when Dr. Charles W. Brabbee not only showed that the condensation method of rating radiators was inadequate but also that the temperature difference between the floor and some fixed position above the floor was needed in judging the performance of steam radiators. At about the same time, unit heaters, with extended surfaces or fins designed for blast heating, were developed to take the place, in some cases, of banks of cast iron or pipe coil radiators formerly used for this purpose.

Finally, during the years 1927 and 1928, Professor A. C. Willard and his staff at the University of Illinois employed new test methods, partly along lines proposed by Dr. Brabbee, to show the comparative heating values of bare and enclosed cast iron radiation.

Meantime another type of steam radiator has been going through the development stage. This new type of radiator is a modification of the extended surface or fin radiator developed for blast heating and is provided with larger fins for use in gravity heating. Some of these gravity types of extended surface radiators are provided with enclosures in one single unit, while others may be fitted with various types of enclosures to suit the particular need. As in the case of the development of the extended surface air blast radiator the results secured are lightness in construction as well as a saving of space. Some test data on these newer type of radiators are available, but to date none of a classical nature has appeared as to performance.

Rating of Radiators

Before we proceed it is best that we thoroughly understand the situation as far as radiators are concerned. The old method of rating was based entirely on the amount of steam condensed per square foot of surface. Dr. Brabbee proved that this method was not satisfactory in that radiators which gave the same condensate at 215 deg. fahr. steam temperature and 70 deg. fahr. room temperature (measured at identical positions above the floor) would maintain different temperature conditions at the floor and ceiling. In other words, the temperature gradient between floor and ceiling would not necessarily be the same per foot height in a given room, where radiators of the same steam capacity were concerned, if the design were different. This simply means that, for the present, our rating methods for steam radiators are in need of skillful laboratory investigation in order that new methods may be evolved which will not only place all types of gravity and of blast radiators on the same basis, but which will also furnish sufficient data by which steam radiators may be judged. In the meantime it behooves all those

interested in design and performance to learn as much as possible about the room temperature characteristics of all radiators under consideration, because any radiator which, under operating conditions, has a high temperature gradient between floor and ceiling is inefficient in design.

One of the interesting relations of steam radiators is that of the breathing line-condensate. It makes no

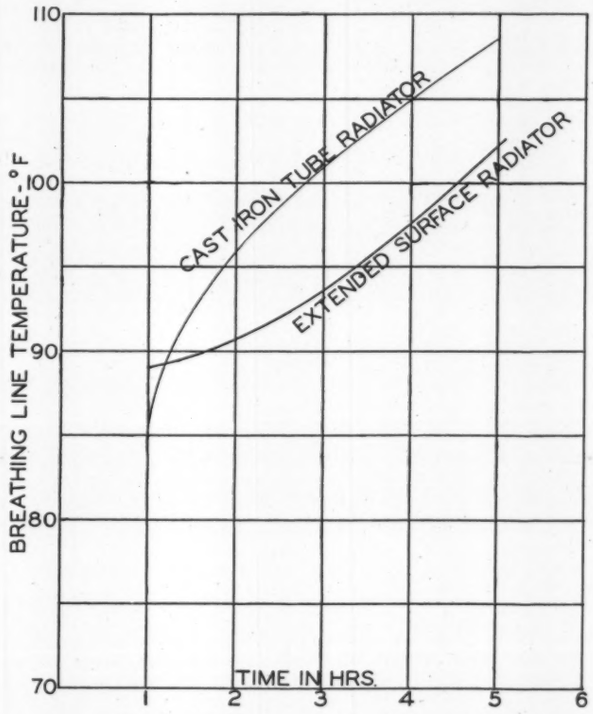


FIG. 2—TEMPERATURE—TIME CURVES

particular difference if one prefers the breathing line-capacity relation, because, if the calculation of capacity in square feet of radiation is made correctly, the results will be the same. In Fig. 1 the breathing line-condensate characteristics of an extended surface radiator and also of a cast iron radiator are plotted. The curve for the cast iron radiator is almost a straight line even at temperatures around 110 deg. fahr. This is a peculiar characteristic of cast iron radiation. It has led to the practice of plotting data actually obtained from the test floor and then extending the curve until it crosses the 70 deg. fahr. breathing line. At that point the rating, in terms of condensate or of square feet of radiation, is read. As it is hardly possible to hold a room at 70 deg. fahr. in the summer, with a steam radiator of proper capacity operating in the room, this method is fairly satisfactory. Some extended surface radiators, such as the one shown in Fig. 1, give a curve which is anything but a straight line. This characteristic requires greater care in plotting the performance. Otherwise the use of refrigeration, to control test conditions, must be secured.

In Fig. 2 is plotted the breathing line temperature-time curves for the same radiators. Here, over a period of five hours, the cast iron radiator gives a temperature rise of 24 deg. fahr., while the enclosed surface radiator shows, for an equivalent time interval, only 13 deg. fahr. This difference in performance is no proof that the enclosed type of radiator gives better results, or poorer results, than radiators of the cast iron type and must not be so interpreted. It does show quite distinctly how radiators of various designs and types can differ. The main fact worthy of note is the difference in the shape of the two curves, which are also peculiar characteristics of these two types of radiators.

Another peculiar relation of radiators is that of humidity-condensate. Very little information has ever been published on this subject, as the correct methods of measuring the humidity have not been understood. Where the mercury thermometer is employed for room temperature and humidity observations, the grade of instrument used must be high or the errors are likely to be sufficiently large to make plotting difficult. The relative humidity-condensate curves shown in Fig. 3, for the two radiators under discussion, need some explanation. In the first place, the moisture content of the room decreased at a uniform rate during the progress of the tests. As the temperature of the room rose the relative humidity naturally was bound to decrease, due to the fact that the increase of temperature of the air increases the ability of that air to hold moisture. Therefore, the curves shown are affected by more than a temperature change, as would be the

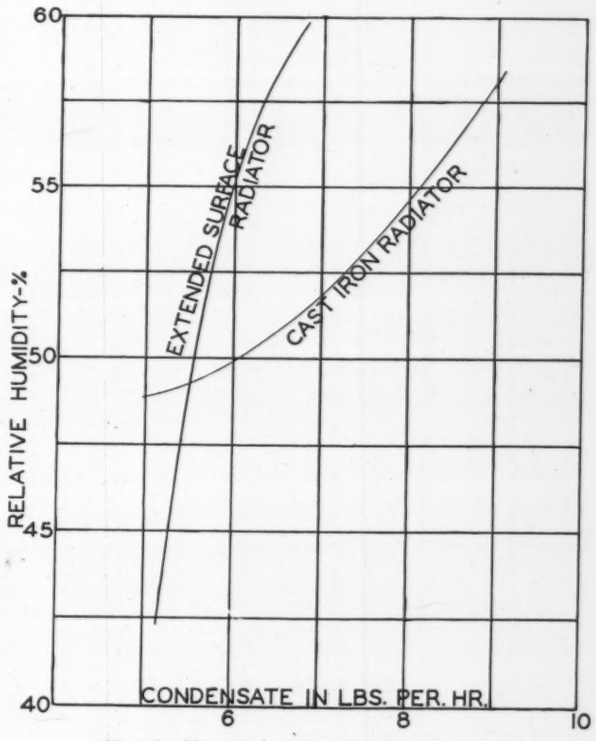


FIG. 3—HUMIDITY—CONDENSATE CURVES

case if no moisture were added or subtracted. We therefore have the effect of relative humidity on radiator performance illustrated by these curves. Had the temperature been held constant, this relation or effect would have been much more easily seen.

A 4300 Ft. High Pressure Steam Line at Trenton, N. J.

A VERY interesting steam fitting job has just been completed at Trenton for the State of New Jersey. The problem was to connect the powerhouse of the New Jersey state hospital for the insane with the powerhouse of the girls' home, by means of a high pressure steam line, so as to enable the State to supply steam to both institutions by operating the state hospital plant only, and effect considerable saving in the operation.

The mechanical plans were designed under the supervision of the department of institutions and agencies of the state of New Jersey.

The installation consisted of the necessary changes in the state hospital power house, the installation of a steam meter, the main conduit line and the necessary changes in the girl's home boiler room to connect the present equipment and buildings to the new line.

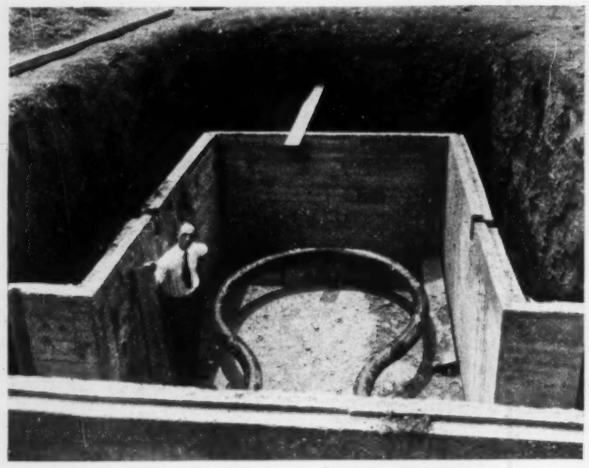


FIG. 1. UNDERGROUND EXPANSION BEND PIT

The conduit line from one powerhouse to the other has a length of about 4300 ft., of which 3700 ft. are underground and about 600 ft. above ground. The material used for this line was 6 in. wrought iron pipe, with joints and connections welded in the field. The line was provided at frequent intervals with double U expansion bends and the necessary anchors. Bends in connection with underground lines were located in large concrete expansion chambers; in connection with exposed lines, on high concrete piers.

The underground lines, resting on rollers, were enclosed in the tile conduit filled with sponge felt insulation. A special 6 in. underdrain embedded in broken stone and gravel runs under the entire length of the underground conduit to take care of the ground water. The exposed line, supported on rollers mounted on concrete piers, was insulated with 3 in. thick molded sponge felt and water proof paper, over which a water proof galvanized steel jacket was installed which was painted with several coats of mineral paint.

The accompanying photographs show various views of this steam line.

The mechanical plans for this installation were designed under the supervision of the Department of Institutions and Agencies of the State of New Jersey.

The mechanical work, steam lines and sheet metal work was installed by Burns-Lane-Richardson Co. of Trenton and New Brunswick, N. J.

FIG. 2. UNDERDRAIN CONDUIT PIPE AT EXPANSION PIT

FIG. 3. COVERING AND BACK-FILLING

Heating·Piping
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American Society of Heating and Ventilating Engineers JOURNAL SECTION

DECEMBER 1929

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Effect of Wind and Weather Conditions on the Heating Loads: R. S. Franklin, *Chairman;* W. L. Fleisher, J. F. Hale, E. B. Langenberg, S. R. Lewis, F. R. Still and A. C. Willard.

Testing and Rating Unit Heaters: D. E. French, *Chairman;* O. K. Dyer, G. E. Otis, H. W. Page, W. A. Rowe, J. H. Shrock and L. C. Soule.

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1929

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1301 Citizens Bldg.
Secretary, R. G. DAVIS
887 Nela View Rd.

ILLINOIS
Headquarters, Chicago
Meets: Second Monday in Month
President, H. G. THOMAS
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Secretary, C. W. DELAND
211 N. Desplaines St.

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Headquarters, Kansas City, Mo.
Meets: Second Monday in Month
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311 Mutual Bldg.
Secretary, F. A. KITCHEN
1011 Pioneer Trust Bldg.

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Meets: First Monday in Month
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125 St. Botolph St.
Secretary, J. S. WEBB
Statler Bldg., Rm. 517

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1346 Broadway, Rm. 502
Secretary, E. H. CLARK
606 Michigan Theatre Bldg.

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Air Conditioning the Halls of Congress

By L. L. Lewis[1] and A. E. Stacey,[2] Jr., Newark, N. J.
MEMBERS

ABOUT 80 years ago the original United States Capitol building measuring approximately 352 ft. × 229 ft. overall, was found to be inadequate for the purposes for which it was designed. Consequently, in 1851, the construction of the present House and Senate wings was begun. The House wing was completed in 1857 and the Senate wing in 1859.

With these wings the overall dimensions of the building are 751 ft. × 350 ft.; the building faces east, with Pennsylvania Ave. extending southward from the grounds in the rear. The north wing is occupied by the Senate and the south, by the House of Representatives. It is interesting to note that originally the Senate occupied what is now the Supreme Court chamber, and the House what is now Statuary Hall.

The two chambers are very much alike but of slightly different dimensions. The Hall of the House of Representatives, measured over the Galleries, is 139 ft. in length, by 93 ft. in width and 36 ft. in height from ceiling to floor. In all, 444 people may be seated upon the floor, the outside dimensions of which are 118 ft. × 68 ft. Attendants increase this number by 25 or 30. In the galleries there are 616 chairs, 240 people may be seated on the steps and there is standing room for 192, so that on important occasions a total of 1,048 people may be crowded into the galleries.

The Senate Chamber is 113 ft. in length, by 80 ft. in width and 36 ft. in height. The normal seating capacity of the floor is 96, and that of the galleries 682. There are about 20 attendants present. Special sessions may bring all or part of both Houses into a joint meeting, at which galleries and floor may be crowded greatly beyond these limits.

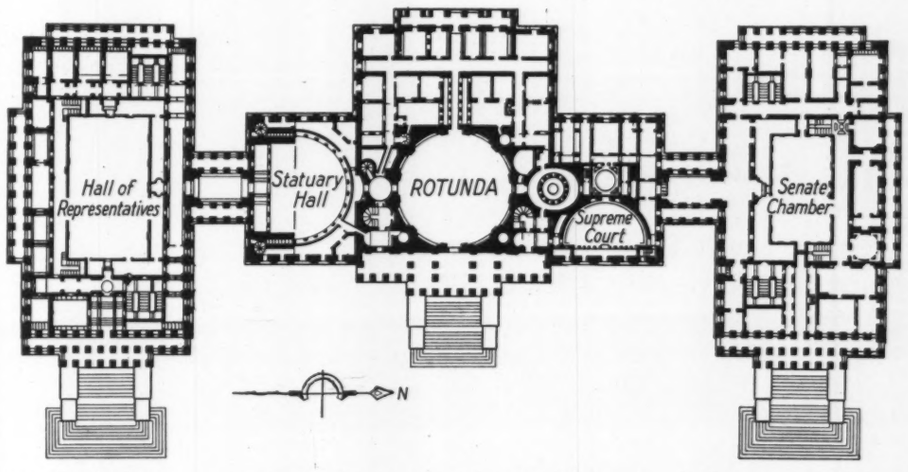

FIG. 1. A DIAGRAMMATIC FLOOR PLAN OF THE CAPITOL SHOWING THE HALL OF THE HOUSE, THE SENATE CHAMBER, THE SUPREME COURT AND STATUARY HALL. THE TERRACES ARE NOT SHOWN

The location of the galleries relative to the floor is shown clearly in Fig. 2. This figure also shows the line of the ceiling, a beamed surface, the panels of which are approximately 8 ft. × 10 ft. The center of the panels are frosted and colored glass, in artistic design.

The beams of the ceiling, a false work covering the lower members of the roof trusses, are made entirely of cast iron, a most unusual material for such a purpose. The panels do not extend entirely to the side walls, there being a fairly wide border around the outer edges, the material for which, again, is cast iron. A roof of glass covers the attic above this ceiling over practically the entire floor. This is the nearest contact which either chamber has with out-of-doors. The glass roof and the glass ceiling permit the entrance of sufficient light to give a most excellent natural illumination.

Artificial illumination for the entire chamber is now obtained with electric lights, arranged in rows around the edges of the glass panels. These lights may be seen in one of the figures showing the duct work in the attic. (Figs. 4 and 5.) It is interesting to note that at one time this artificial illumination was obtained with some 1,400 gas jets, located in the attic space.

Partly surrounding the floor, and covered by the galleries, are two cloak rooms, the one Republican, the other Democratic. These are "L" shaped, the two longer sides making up the full length of the floor and the shorter sides extending approximately to the center of the shorter side of the floor. While no smoking is permitted on the floor, and, of course, in the galleries, the Congressmen may be completely at ease in the cloak rooms.

Numerous entries in the *Congressional Record* dating back to 1870 show that there has been a continuous and vital interest in the heating and ventilating systems which were first installed when the wings were constructed, and which have been modified from time to time, in order to keep these

For presentation at the 36th Annual Meeting of the American Society of Heating and Ventilating Engineers, Philadelphia, Pa., January, 1930.

[1] Secretary and Consulting Engr., Carrier Engineering Corp., Newark, N. J.

[2] Vice-president-Charge of Research, Carrier Engineering Corp.

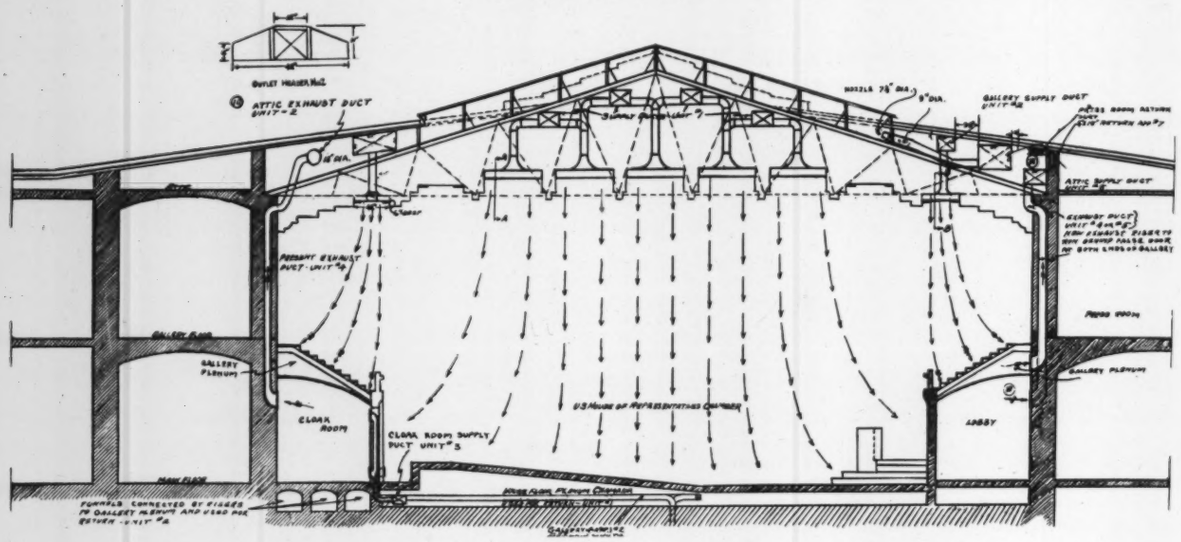

FIG. 2.—A TRANSVERSE SECTION. THE SPEAKER ON THE RIGHT FACES TOWARD THE CLOAK ROOMS. OPENINGS FROM THE FLOOR TO THE EXHAUST CHAMBER BENEATH ARE NOT SHOWN

systems in line with the development of the art, if not well in advance of it.

The scope of the new work was the installation of equipment to air-condition the floor, the chamber, the galleries, the cloak rooms and the press rooms. The systems are designed to cool the conditioned spaces to a temperature of 75 deg. fahr., with a relative humidity of 40 per cent. In winter the systems are capable of heating to 80 deg. fahr. and coincidentally maintaining a relative humidity of 50 per cent.

The spaces in which these air conditions are maintained are almost completely shielded from all outside weather variations. Figs. 1 and 2 show that the chambers and cloak rooms are entirely surrounded by the corridors and rooms of the Capitol Building. These enclosing rooms are heated in winter, and in summer will have a temperature approaching that of out-of-doors. The principal duty of the systems conditioning the chambers and cloak rooms is, therefore, to absorb the heat given off by the occupants.

This requirement varies widely and quickly as the people gather first in one place and then another. During an executive session, for instance, the public is excluded and the galleries are empty. During ordinary routine a few tourists are scattered about the galleries; the floor may be sparsely occupied and the cloak rooms crowded with smokers and conferees. A quorum is called for and the cloak rooms are deserted. All of these changes must be promptly met, and counteracted with changes in the cooling power of the supply system.

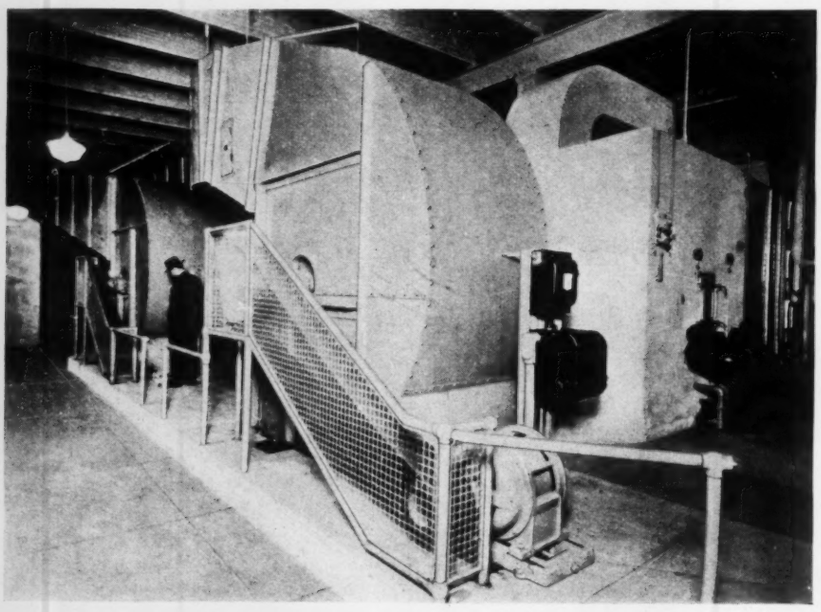

FIG. 3. APPARATUS 1 IS IN THE FOREGROUND. THE MAN LOOKING AT THE DRIVE OF FAN 2 IS FACING TOWARDS THE INLET OF FAN 7. THE DUCT RISING DIRECTLY IN FRONT OF THE COLUMN LEADS TO APPARATUS 3

The installation in the House, which was ready for the short session in December, 1928, and that in the Senate which was first operated in August, 1929, are so very much alike that it seems wise to deal only with the larger of the two installations.

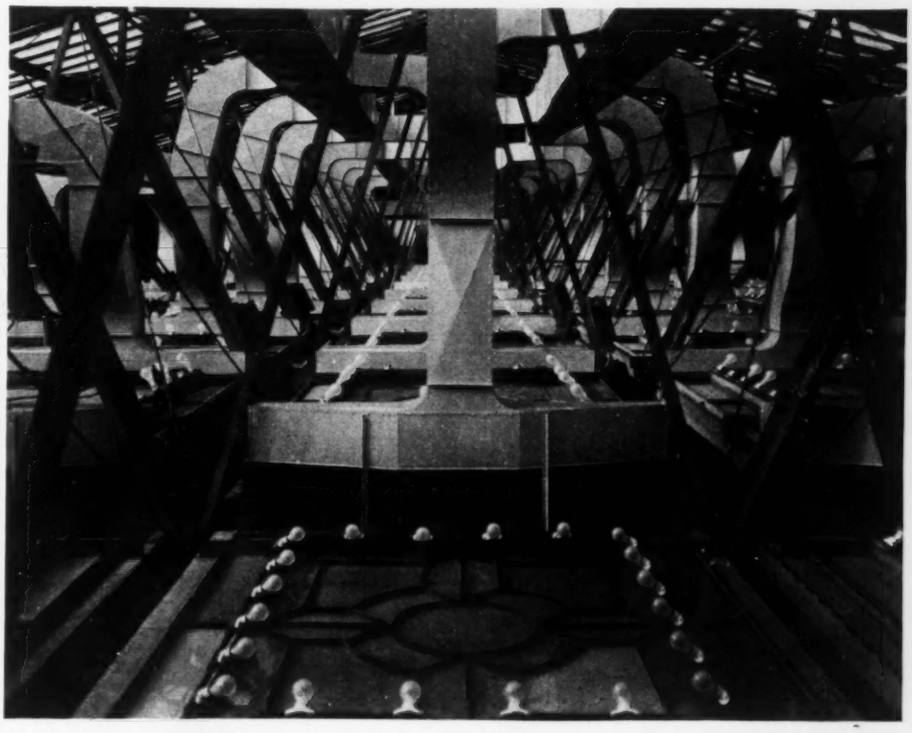

FIG. 4. THE ATTIC FROM A POINT ON THE LONGITUDINAL CENTER LINE. THE COMPRESSION MEMBERS OF THE ROOF TRUSSES ARE CAST IRON

Seven systems are required for complete operation. Of these, five are supply systems, one serving the floor of the House, the second, the galleries, the third, the cloak rooms, the fourth, the attic space, and the fifth, the press rooms. The press room apparatus is independent of the other systems excepting that it receives cold water from the central refrigerating plant. The sixth apparatus is an exhaust system for the removal of air, and the seventh, a forced circulation condenser water cooler for the refrigerating machine.

The problem was so to balance the supply and exhaust that an excess of air would be brought in with the great central stream descending upon the floor and expanded outward to be exhausted through floor openings under the gallery seats. The effect of this is completely to isolate the occupants of the floor from those of the galleries. Thus, one, unfortunate in the possession of a common cold, could enter the gallery to see and to hear and in no way subject a member to the possibility of infection.

A total volume of 36,000 cu. ft. per min. is supplied by the apparatus serving the floor, that is, from system 1. An equal volume is supplied by system 2, serving the galleries. Approximately half of the volume of air handled by system 1 may always be taken from out-of-doors, this coming through a tunnel terminating

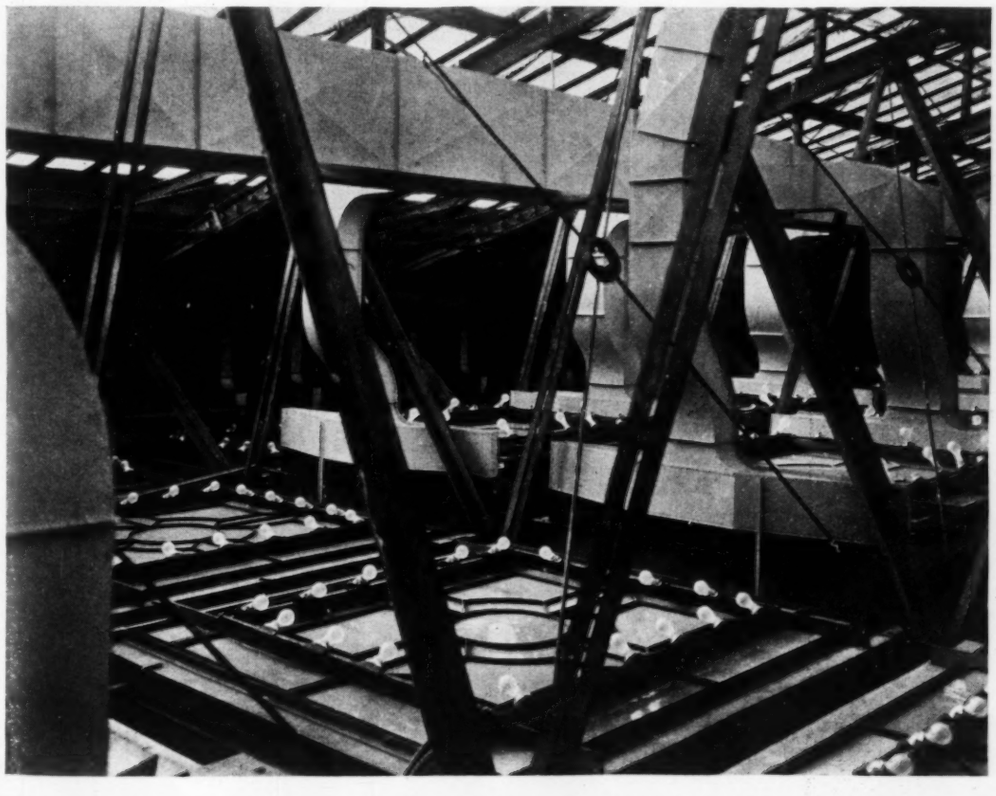

FIG. 5. ANOTHER VIEW OF THE ATTIC. THE GALLERY OUTLETS AND HIGH VELOCITY NOZZLES FOR THE ATTIC ARE IN THE BACKGROUND

in a tower intake located about 500 ft. from the apparatus in the grounds at the rear of the building. A small amount of recirculation is taken from an exhaust chamber under the floor of the House.

Introducing the Air

The problem of determining a proper method of introducing the air overhead was greatly complicated by three factors; first, that no one had any desire, had it been possible, to change any of the architectural features of the ceiling; second, that grilles or registers were considered too obviously out of harmony with the architecture to be permitted; third, whatever duct work was placed in the attic must not cast any shadows upon the glass ceiling.

Fortunately, many of the decorative features of the ceiling were fastened with bolts. The glass panels were framed in heavy wrought iron and these frames could be raised sufficiently to provide space for headers to distribute the air around the edges of the panels. The light and shadow problem was solved by a multiplicity of horizontal and vertical ducts, located as shown in Figs. 4 and 5. Reflection and diffusion of light was increased by painting with a light enamel paint.

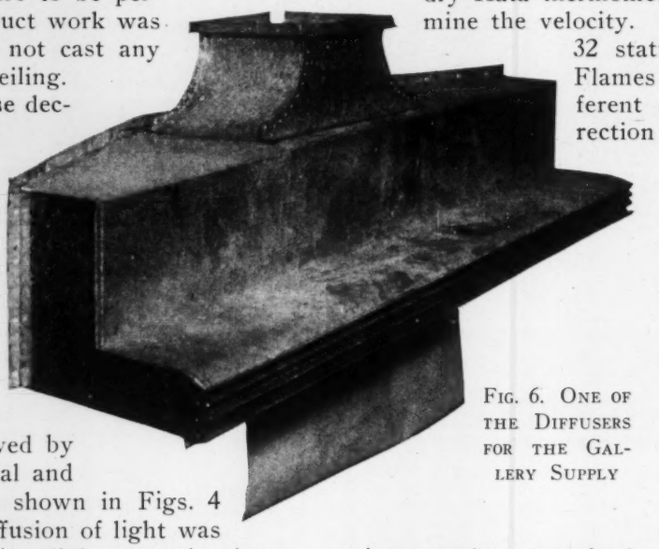

FIG. 6. ONE OF THE DIFFUSERS FOR THE GALLERY SUPPLY

Congress is largely made up of members who, having passed beyond the vigor of youth, are sensitive to air circulation. The necessity of making these gentlemen comfortable and the handicaps imposed by architectural features, required that all opinions and theories of the effects of distributing devices, of which Fig. 6 is an example, should be proved prior to installation. Therefore, the important physical features of all questionable sections were duplicated, and diffusers built to various designs and proved experimentally. Figs. 7 and 8 represent section of the ceiling. All tests were conducted with a normal differential of air density for the systems. Observations were made both with smoke and the flames of many candles.

Static Pressure Regulator

The widely varying demands for cooling effect in the area served are met with directly proportional variations in the density of the air delivered from outlets relative to the density of the air in the chamber. Thus, the tendency of the air to fall bears a direct relation to the cooling work. A slight increase in the velocity of air delivered at maximum density would have a large effect in increasing circulation. An excess is guarded against automatically with a static pressure regulator. This insures a constant supply of air, a constant distribution and effectively prevents the air movement in the occupied zones from exceeding a predetermined maximum velocity.

Before placing these systems in commission, careful tests were run on each set of apparatus. As the most tedious and difficult part of the task was balancing the distribution of air at the 90 headers in the ceiling, this was finished first. The static pressures in the header for different capacities had been determined in the laboratory. Volume dampers had been installed in the supply ducts to the headers. These were adjusted to give the proper pressure in each header. A pitot-tube and a sensitive draft gage were used to measure the pressures.

Due to the low air movement in the chambers, dry Kata thermometers were used to determine the velocity. Readings were taken at 32 stations covering the floor. Flames of candles placed at different points indicated the direction of air movement in the breathing zone. Where necessary, adjustments were made in the openings through the floor to the exhaust chamber beneath. This method effectively balanced the air flow over the chamber. Complete volume tests were carried out on all systems, standard practice being followed.

The resistance thermometers of the 16 point recorder were checked against precision grade glass thermometers graduated to 0.25 deg. fahr. The recorder was found correct within 0.5 deg. fahr.

The Ducts

The more important systems are located in the basement room shown on Fig. 9, many feet from the chamber. All of the supply ducts from systems 1, 2 and 3 had to pass through tortuous passages, through heavy stone foundations, and upward through existing flues to the attic space.

It was not possible in every case to run the ducts through the available passages without some modification, and in one case it was necessary to cut through 8 ft. of blue stone foundation wall. Two men, assisted by every ordinary means, excepting explosive, spent 18 days enlarging one opening through this wall. In another case it was necessary to utilize the full area of one old smoke flue. The lining of this flue was impregnated with the products of combustion. To remove offensive odors, one and a half courses of the brick lining of this flue were chipped off in order to remove the impregnated portion. The clean surface was then waterproofed, rough plastered and finally covered with a smooth plaster finish.

In order to eliminate soot and smoke as well as dirt, all of the air is passed through oil filters. System 2 supplies 6,000 cu. ft. per min. to the two cloak rooms, a portion of this being taken from the recirculating passage of system 1. Under maximum load the other portion is conditioned air taken from the

dew point chamber of system 1. The interesting feature of the cloak room system is that all of the air can be delivered either at the floor or ceiling. Part of the air is now being delivered at the floor and part at the ceiling.

System 4 exhausts 18,000 cu. ft. per min. of which 6,000 cu. ft. per min. is removed from ceiling grilles in the cloak rooms and 12,000 cu. ft. per min. from the floor opening in the galleries. The air may be discharged directly out-of-doors, or first used in system 5 to cool the attic space. This 6,000 cu. ft. per min. added to the 12,000 cu. ft. per min. taken from the exhaust chamber under the galleries, makes up the 18,000 cu. ft. per min. total capacity of system 4. This air may then either be blown out-of-doors or into the inlet stream of system 5, the attic supply system.

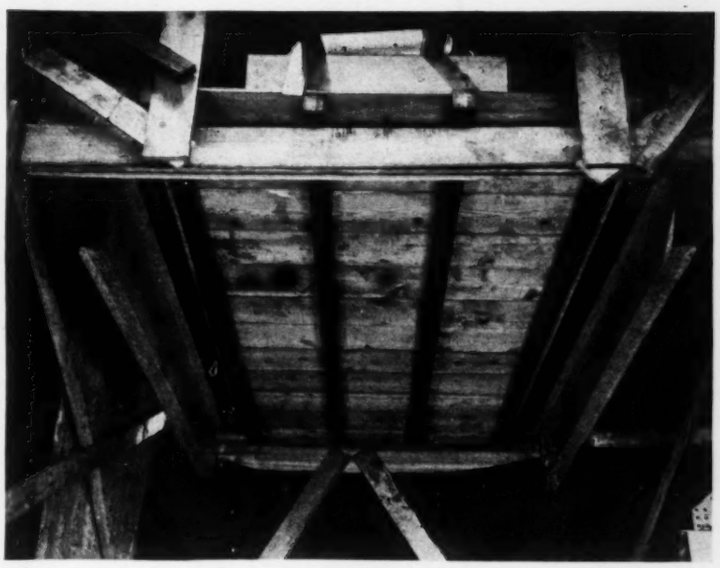

FIG. 7. LOOKING UPWARD INTO THE DIFFUSER SLOTS OF A FLOOR OUTLET IN THE EXPERIMENTAL SET-UP

Attic Supply System

The attic supply system is probably the most interesting of all. It serves the triple purpose of utilizing the air from the chamber to cool the attic space, thereby forming a barrier between outside conditions and the chamber proper. It heats the attic space whenever necessary to prevent the glass ceiling from cooling the upper strata of air in the chamber, and in severe weather it maintains a relative humidity and air movement underlying the glass roof, which will prevent condensation on the surface.

The absolute humidity in the attic might be raised to a point approaching that of the chamber by leakage through the paneled ceiling, so in winter the inner surface of the roof is swept with a current of warm, dry air which keeps the surface temperature below the dew-point. In summer, the used air taken from exhaust system 4 is delivered through a second set of outlets designed not to sweep the roof but to cool the lower portion of the attic while leaving the hot strata undisturbed in the upper section.

Thus the temperature fluctuations in the attic space are greatly reduced, thereby relieving the automatic regulation of the floor and galleries, reducing the radiation losses from the attic duct work and reducing the temperature head at which air must be delivered.

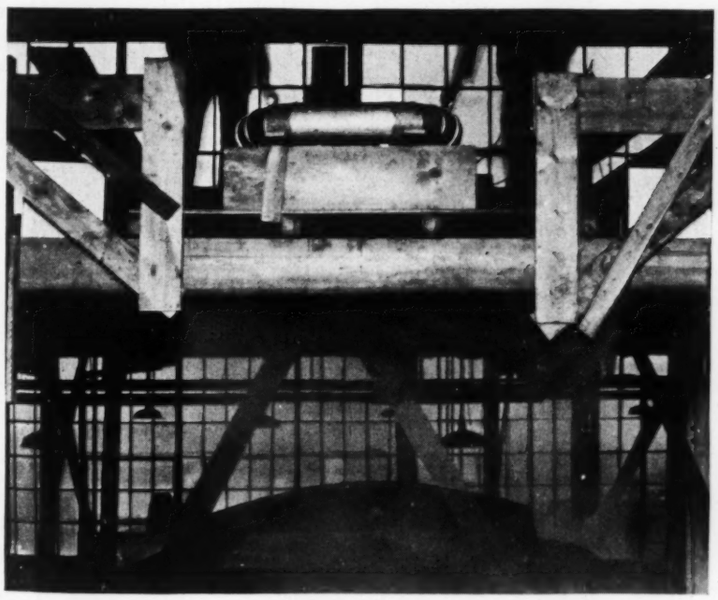

FIG. 8. THE EXPERIMENT WITH SMOKE WHICH IS BEING CARRIED SLIGHTLY TO THE RIGHT BY A GENTLE AIR MOVEMENT IN THE LABORATORY

Temperature Control

The automatic temperature controls installed were designed to meet the unusual conditions previously outlined. For instance, the thermostats controlling the heaters in systems 1 and 2 are located over 200 ft. from the apparatus. To prevent the long air lines connecting the thermostat and the diaphragm valves from causing an appreciable lag in the operation of the instruments, some means were required to increase the air capacity of the thermostats. For this reason, air relay valves, which multiplied their effective sensitivity several times, were installed near the thermostats.

A thermostat located in the return air passage controlled the volume of air passing through the dehumidifier. To counteract these changes, a static pressure regulator, designed for finely graduated action, alters the position of the recirculating dampers slightly to maintain constant the amount of air discharged by the fan.

Maximum and minimum temperature thermostats are installed in the supply duct, to limit within predetermined ranges the temperature of the air entering the conditioned spaces. These are necessary to maintain the air distribution at the breathing line. A standard dew-point control is used. This is so familiar no description is given.

The sensitive bulbs of the thermostats controlling the tempering coils are located in the outside air duct. As the tempering coils are divided into two parts, an individual thermostat is connected to each section. One thermostat is set to operate at a temperature near the freezing point and the other at 20 deg. fahr.

Systems 1, 2 and 6 are controlled as previously outlined with the exception that the static regulator was unnecessary on system 6.

The temperature of each cloak room is controlled by a thermostat placed in the room and operating the steam valve on the heater located in the basement. The temperature in the attic space is controlled during the heating period by a thermostat located in the center of the attic, which varies the steam admission to the heaters of system 5. This thermostat is shielded from the direct rays of the sun by white asbestos.

System 6 delivers 7,000 cu. ft. per min. to the five press rooms. The apparatus is located in the attic near the press rooms and is a replica of systems 1 and 2, except that a static regulator was considered unnecessary. Air is delivered from this apparatus through pan outlets centrally located on the ceiling and spreading cool air uniformly in all directions. Each one of these rooms contains an old fireplace through the flue of which air is relieved.

Refrigerating Equipment

A refrigerating machine, the capacity of which is 206 tons, is placed in a room near the main apparatus room and shown in Fig. 10. It is interesting to note that if all outside air were used instead of partial recirculation there would have been needed 486 tons of refrigeration to maintain the same air conditions in the chamber. The compressor of this machine is driven by an 1,800 r.p.m. alternating current variable speed motor, connected through increasing gears. In order to prevent the noise from the motor and gears from reaching the corridors of the building, this refrigerating machine is entirely enclosed in a room having large windows to permit observation from various points in the apparatus room.

Completely enclosing the refrigerating machine added the complication of removing the heat generated by the motor, radiated from the warmer portions of the condenser, and given off by the resistance grids of the motor controller. Air is admitted through a sound absorber and exhausted from a hood directly above the resistance grids.

Condensing water could not be taken from the city mains, because of an insufficient supply. It was quite impossible to find any location in which either a spray pond or a cooling tower could be hidden on the roof of the building. Such equipment would have been entirely out of harmony with the archi-

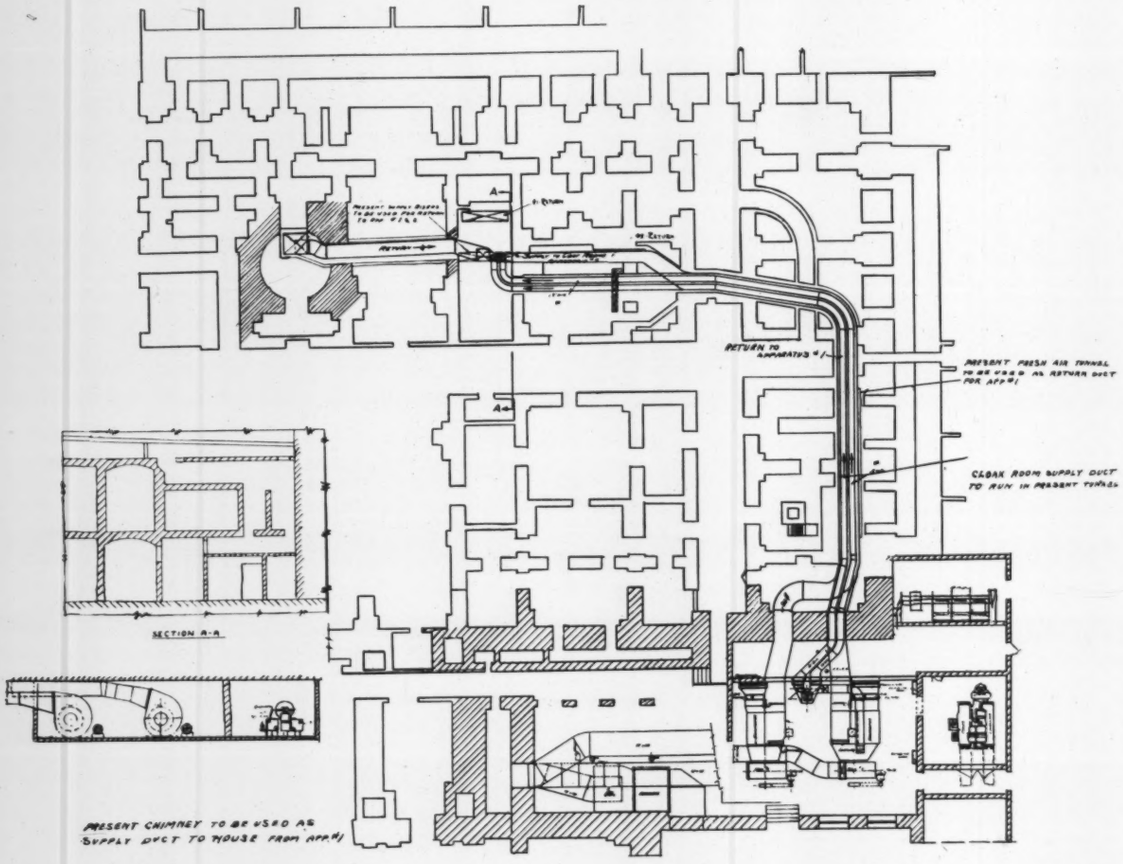
RETURN TO APPARATUS #1
CLOAK ROOM SUPPLY DUCT TO RUN IN PRESENT TUNNEL
SECTION A-A
PRESENT CHIMNEY TO BE USED AS SUPPLY DUCT TO HOUSE FROM APP. #1

FIG. 9. A PLAN OF THE BASEMENT SHOWING THE GENERAL ARRANGEMENT OF APPARATUS, DUCTS AND REFRIGERATING MACHINERY

tecture and purpose of the building. To meet this condition, system 7 was installed. This consists of a fan drawing 49,000 cu. ft. per min. from an interior court through an air washer and discharging it through a vertical flue rising to the roof. The exhaust from the refrigerating machine room is connected to the inlet of the same fan.

In both the condenser and the cooler of the refrigerating machine the water passes through small tubes in a completely closed circuit. The condenser water pump, therefore, withdraws water from the tank of the condenser water cooler of system 7, and forces it through the condenser and back to the sprays, under pressure. A single pump withdraws the used cold water from the tanks of systems 1 and 2, and likewise pumps through the cooler to the sprays. A third pump supplies the necessary volume of cold water to the press room system in the attic. All horizontal runs of water piping are placed in trenches beneath the floor.

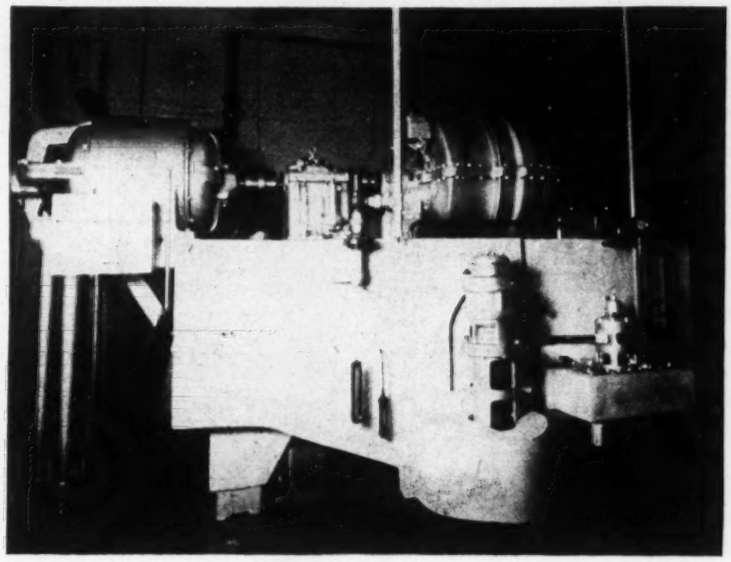

FIG. 10. LOOKING AT THE REFRIGERATING MACHINE THROUGH ONE OF THE OBSERVATION WINDOWS

For ideal operation, all of the seven systems and the refrigerating machine should have been located within a single room, but this was impossible. With the exception of the press room system the essential features of this plan were put into effect. An operator must ascend to the attic to start and stop the two fans in the attic, but otherwise they can be depended upon to operate without attention.

There are points in the apparatus room from which the refrigerating machine, the condenser water cooler, supply systems 1, 2 and 6, all pumps and the air compressors can be seen. A temperature recorder which automatically prints 16 temperatures upon a broad tape is prominently located on one wall so that the operator may at all times know exactly how the plant is operating.

The Institution of Heating and Ventilating Engineers.

SECRETARY: H. B. WATT.
TELEPHONE: FITZROY 1081.
TELEGRAMS: WATT, 12, RUSSELL SQUARE, LONDON.

PRESIDENT: J. ROGER PRESTON.

HBW/JM.

12, RUSSELL SQUARE, LONDON, W.C.1.

A.V. Hutchinson, Esq.,
Secretary, American Society of
Heating & Ventilating Engineers,
29 West Thirty-ninth Street,
New York, U.S.A.

11th October 1929

Dear Mr. Hutchinson,

Referring to your kind letters of 2nd July and 8th September last, I have great pleasure in advising you that the beautiful, illuminated Address of Greeting which the President of your Society, Mr. Thornton Lewis, handed to the President of this Institution on his recent visit to London, has now been circulated at a meeting of members of our Council, and also reported to a general meeting of Members on the 8th October.

These were the first official meetings held since the receipt of this Address, and I was instructed to convey to you the sincere appreciation of the Council and of the Members for the friendly message and brotherly greetings which are expressed and to say, in the name of the Institution, that these are very highly esteemed and valued.

It may interest you to know that the Council ordered the Address to be framed suitably, and hung on the walls of our Council Room here, and this is being done.

The Council reciprocated all the good wishes expressed, and send their best wishes for the continued prosperity and success of your Society.

With compliments,
I remain,
Yours truly,

H B Watt

50th Anniversary of A. S. M. E.

The 50th Anniversary of the *A.S.M.E.* is to be celebrated in April, 1930, in New York, Hoboken and Washington, D. C.

Hoboken is the birthplace of the society and its headquarters are in New York.

In New York, the delegates, members and guests will register at the Engineering Societies Bldg., on Saturday, April 5. This will be followed by the unveiling of a tablet in the lobby of the building in commemoration of the Anniversary, and then the party will be taken to the offices of *The American Machinist* where a program will be given.

In the afternoon the anniversary program will be continued at Stevens Institute, Hoboken, with a pageant featuring the organization meeting of the *A.S.M.E.* held in that auditorium in April, 1880.

The program is again taken up in New York on Sunday, April 6, when special commemorative services will be held at the Cathedral of St. John the Divine. Following the services the delegates leave for Washington, D. C. There the headquarters will be at the Mayflower Hotel and the meetings in the U. S. Chamber of Commerce buildings.

The following three days will be devoted to Sessions of great importance to all the delegates, including a series of trips to points of scientific and engineering interest such as government buildings, Bureau of Standards, Smithsonian Institution, the Navy Yard, etc.

NOMINATIONS FOR OFFICERS OF THE SOCIETY FOR 1930

Your Committee appointed to prepare nominations for Officers of the Society for the coming year, 1930, takes pleasure in submitting the following list of nominees:

For President:

L. A. HARDING, 1335 Main St., Buffalo, N. Y.

For First Vice-President:

W. H. CARRIER, Newark, N. J.

For Second Vice-President:

F. B. ROWLEY, University of Minnesota, Minneapolis, Minn.

For Treasurer:

C. W. FARRAR, Buffalo, N. Y.

For Members of the Council:

Three-Year Term

R. H. CARPENTER, New York, N. Y.
JOHN D. CASSELL, Philadelphia, Pa.
ALFRED KELLOGG, Boston, Mass.
JOHN HOWATT, Chicago, Ill.

Respectfully submitted,

NOMINATING COMMITTEE

FREDERICK D. MENSING, Chairman

C. E. BRONSON — JAY R. McCOLL
R. C. BOLSINGER — O. K. DYER
H. B. HEDGES — EDWIN C. EVANS, Sec'y.
H. M. NOBIS

In accordance with the provisions of the Amended Constitution, as given, ballots containing the names of the above candidates will soon be sent to the membership for voting upon prior to the Annual Meeting in January.

Art. 9—*Section* 2. The Nominating Committee shall consist of a member designated by each Chapter, which shall effect its own organization and elect is own Chairman.

Section 3. The Committee may meet at the call of the Chairman, for discussion, but the official meeting shall be held at the Semi-Annual Meeting of the Society, at which time the candidates for each of the offices of the Society to be filled at the next Annual Meeting shall be selected by a majority vote of the members of the Committee present and voting. Five shall constitute a quorum.

Section 4. The Committee shall first secure the consent of all candidates selected, and shall if possible announce the names of the candidates at the Semi-Annual Meeting, but in any case the names of the candidates shall be certified to the Secretary of the Society at least four months before the next Annual Meeting. The Secretary shall publish these names in the October issue of THE JOURNAL.

Art. 10.—*Section* 3. The Secretary shall prepare ballots with the names of all candidates and forward them to the members, at least thirty (30) days before the date of the Annual Meeting.

Nominations for Members of Committee on Research

Although committees of the Society are usually appointed, in view of the great importance of the Committee on Research and the financial responsibility it would be called upon to assume, it has been made more representative of the entire membership of the Society by a process of *election.* The election is governed by the By-Laws for the election of officers, with the single exception, that Members of the Committee on Research are nominated by the Council instead of by a Nominating Committee. In accordance with the Regulations for the government of the Research Laboratory, adopted at the January, 1919, Meeting, the Council announces the nomination of the following members of the Committee for election to succeed those members whose present terms expire January 1930:

C. V. HAYNES, Philadelphia — F. N. SPELLER, Pittsburgh
W. T. JONES, Boston — A. C. WILLARD, Urbana, Ill.
J. F. McINTIRE, Detroit

The regulations governing the nomination and election of members of the Committee on Research are as follows:

2. ELECTION.

a. That the Council shall nominate previous to October 1 of each year, five members to fill vacancies of those retiring at the next Annual Meeting.

b. That the nominations made by Council shall be published in the October JOURNAL of the Society.

c. That prior to December 1 of any year, any ten members, over their own signatures, may nominate one or more additional members for the Research Committee, and such additional nominations shall be placed on the ballot opposite such of the nominations made by the Council as designated by those making the nomination.

d. The election shall otherwise conform to the same regulations as are provided for the election of officers.

e. Vacancies may be filled by the Council, such persons, chosen by the Council, to serve until a successor can be elected at the next annual election.

Effects of Air Velocities on Surface Coefficients

By Frank B. Rowley, A. B. Algren[1] and J. L. Blackshaw[2], Minneapolis, Minn.
MEMBERS

The results of co-operative research work between the A. S. H. V. E. and the University of Minnesota

THIS paper, which relates to the effect of air velocities on surface coefficients, is the result of a part of the co-operative research work between the AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS and the University of Minnesota. The problem of experimentally determining these coefficients is one which requires the control of several variables, and, also, one which is difficult of exact solution.

The surface coefficient of heat transmission (f) is defined as the number of British thermal units which will flow between one square foot of the surface of the material and the surrounding air per hour per degree difference in temperature between the surface and the air. This definition is direct, but before the coefficients can be determined experimentally there are some of the factors which must be more definitely defined. First, the surface temperature, which is a rather definite quantity, is difficult to determine experimentally, due to the effects of other temperatures. If, for instance, the thermocouples are embedded in the surface, there is the danger that the temperatures recorded will be that of the material below the surface and not of the surface proper. This may be an appreciable factor in materials of low conductivity. If the thermocouples are placed directly on the surface, there is the danger that they will be affected by the air temperature, which may also lead to an appreciable error. After some experimental work, the method selected was to place the thermocouples on the surface of the material and cover them with a thin vellum paper.

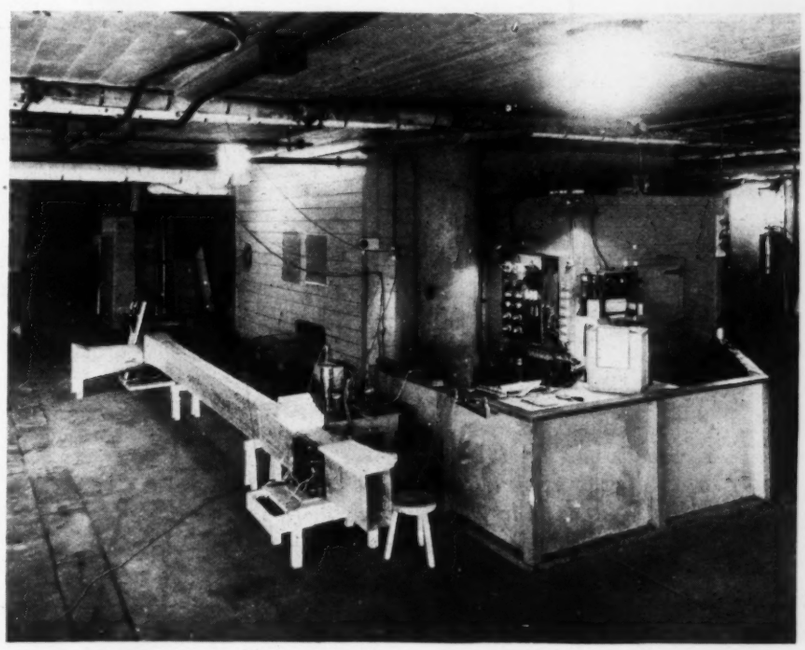

FIG. 1—SURFACE COEFFICIENT TEST APPARATUS AS FIRST SET UP

The second question which arises in determining the surface coefficients is that of where to take the air temperatures. These temperatures vary with the distance from the surface, and some standard distance must be selected. As will be discussed later, temperatures were taken for different air velocities at distances from the surface varying from 0.05 in. up to 4 in. It was found that from 0.5 in. out these temperatures were substantially constant. Therefore, 1.0 in. was selected as the normal distance from the surface for which calculations of surface coefficients were made.

A third point which must be considered is that of air velocities. When we consider the effect of wind on the surface of a material, the question arises as to what angle this wind strikes the surface. It may be parallel to the surface or at any angle up to 90 deg. In any event, it is a question as to how and where to measure the velocity of the air. While this velocity will vary with the distance from the surface, it will also depend upon the direction of the wind. In order to standardize on some practical condition, the velocities were produced parallel to the test surface and measured in this line.

After the test conditions were selected, an apparatus was built up as shown in the photograph of Fig. 1 and in the line drawings of Figs. 2 and 3. Fig. 1 shows the apparatus as first set up at the side of the hot box test apparatus. In this case, air at room temperature was used, but it was found impossible to get sufficient variations in mean temperatures between the test surface and the air. For this reason, the apparatus was re-set as shown in Fig. 2. The fan was placed in the cold storage room and the air from the test apparatus was brought back to the room through a return bend. Thus the air temperature could be controlled for any range, and with reasonable insulation on the pipes there was very little

[1] Assistant Director of Experimental Engineering Laboratories.
[2] Research Assistant.

For Presentation at the 36th Annual Meeting of the AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS, Philadelphia, Pa., January, 1930.

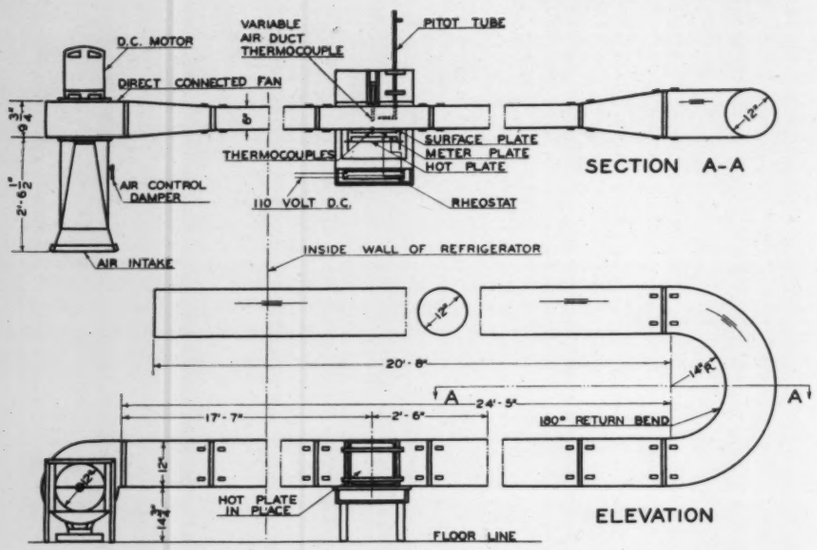

FIG. 2—PLAN AND ELEVATION OF TEST APPARATUS FOR DETERMINING SURFACE COEFFICIENTS WHEN AIR FROM REFRIGERATOR ROOM WAS USED

heat loss. With the exception of air temperature control, the two set-ups as shown in Figs. 1 and 2 were substantially the same.

Referring to Figs. 1 and 2, the air velocity was furnished by a fan driven by a direct connected 220-volt, variable speed, direct current motor. The air from the fan was delivered to a 6 in. x 12 in. rectangular duct and passed for a distance of 17 ft., at which point a 12 in. x 12 in. opening was provided in the side of the duct for the insertion of the test specimen. From this point, the air passed through a short length of straight pipe, from which it was delivered to the open room for the set-up of Fig. 1 and from which it was returned to refrigerator room for the set-up of Fig. 2. The object in either set-up was to provide air at specific temperatures and velocities passing over a test surface which was inserted into the open side of the air duct flush with the inside surface.

The arrangement of the test section proper can be best explained by referring to Fig. 3. The test surfaces used were made up of materials 12 in. square and placed in contact with a meter plate which was substantially the same as the Nicholls' heat meter. The meter with the test material in contact was placed in the opening provided in the side of the air duct in such a manner as to bring the test surface of the material just flush with the inside surface of the duct. Thus the air was passed over the test surface in a line parallel to the surface.

The velocity of the air was measured by a pitot tube, which was so arranged that the velocity could be determined at any distance from the test surface. For low velocities, the Wahlen gage was used, and for the high velocities about 800 ft. per minute an ordinary inclined Ellison draft gage was used. The air temperatures were measured by a fine copper constantan thermocouple, which was arranged to be set at variable distances from the test surface. These temperatures were measured by the use of a potentiometer.

With this apparatus it was possible to get different air temperatures and velocities over the test surface and also to control the temperature of the surface.

The length of straight duct preceding the test surface was sufficient to reduce the turbulence from the fan and to give a reasonably straight line flow over the test surface.

In making the tests, the desired conditions, such as surface temperature, air temperature, and air velocity were first selected and the apparatus was adjusted to give these conditions. It was then allowed to operate for a sufficient length of time to get uniform test conditions and readings were taken for the run. After the temperature drop across the heat meter had been measured, with the aid of the calibration curve for the meter, the amount of heat passing from the test surface could be directly obtained. The surface temperatures were also taken with copper constantan thermocouples and the potentiometer.

The mean temperature was calculated between the air and surface temperatures. The surface conductance was calculated by dividing the number of heat units passing from each square foot of the test surface per hour by the temperature difference between the surface and the air.

There is no specific distance from the test surface at which air temperatures and velocities should be measured. A distance should, however, be selected at which representative results will be obtained under various conditions of wind velocities and mean temperature. In order to determine this distance, many tests were run, using different surface temperatures, air temperatures, and air velocities. In each case, the temperatures were measured at distances from the surface, varying from 0.05 in. to 4 in., and the air velocities were measured at distances varying from 0.125 in. to 5 in. from the test surface. The results for a part of these tests are

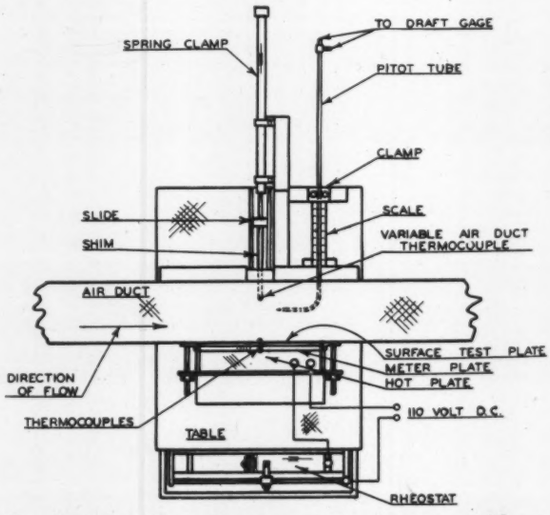

FIG. 3—PLAN VIEW SHOWING ARRANGEMENT OF METER PLATE, TEST SPECIMEN, THERMOCOUPLE AND PITOT TUBE IN RELATION TO AIR DUCT

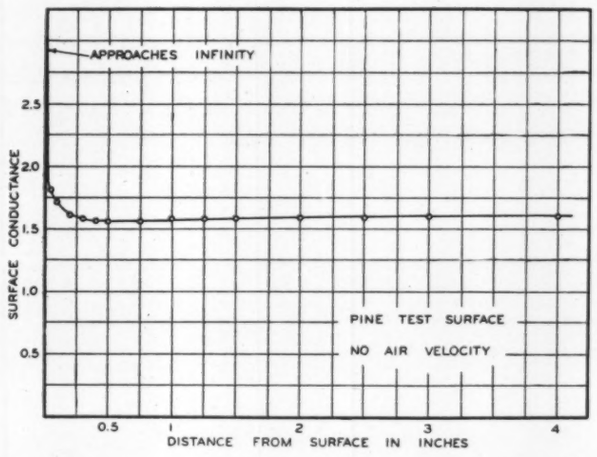

FIG. 4—RELATION BETWEEN SURFACE CONDUCTANCE AND DISTANCE FROM SURFACE AT WHICH AIR TEMPERATURES ARE TAKEN FOR PINE TEST SURFACE AT ZERO AIR VELOCITY AND 65 DEG. FAHR. MEAN TEMPERATURE

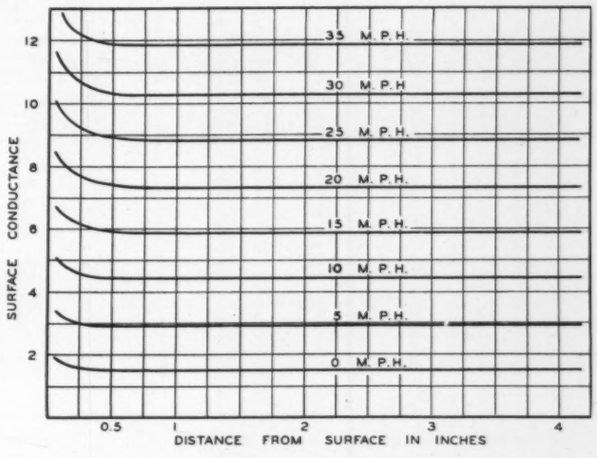

FIG. 5—RELATION BETWEEN SURFACE CONDUCTANCE AND DISTANCE FROM SURFACE AT WHICH AIR TEMPERATURES ARE TAKEN FOR PINE TEST SURFACE AT VARIOUS AIR VELOCITIES AND 65 DEG. FAHR. MEAN TEMPERATURE

shown in Figs. 4 and 5. Fig. 4 shows the surface coefficient for a pine surface at zero air velocity and at a mean temperature of 65 deg. fahr. Fig. 5 shows the surface coefficient for the same surface at air velocities varying from zero to 35 miles per hour and mean temperatures of 65 deg. fahr. In both cases, air temperatures were taken at distances up to 4 in. from the test surface. For tests with moving air, the center of the duct was selected as the proper point for velocity measurements.

An analysis of these curves shows that at a distance of 0.5 in. from the surface, the surface coefficients have reached a constant value. One inch was therefore selected as a reasonable distance at which surface temperatures should be taken for further tests. Fig. 6 shows similar coefficients as determined by the hot box apparatus, with an air velocity of 0.6 miles per hour. With this apparatus, it will be noted that uniform conditions were not reached until about 1½ in. distant from the wall. This difference may be accounted for partially by the unobstructed space in front of the test section. For the hot box apparatus, the nearest obstruction surrounding the test surface was about 10 ft. away, while for the present test apparatus it was only 6 in. away. A further point to be observed in both Figs. 4 and 6 is that as the distance is increased the coefficient gradually increases. This apparent increase in the coefficient may have been caused by convected air currents acting on the thermocouple.

With the test apparatus as described, surface coefficients were obtained for two surfaces: first, a plaster surface in which the thermocouple was embedded flush with the surface; and second, a pine surface. The pine surface was tested both with a thermocouple embedded and also with a couple placed on the surface and covered with vellum paper. For these surfaces, the effects of wind velocities and mean temperatures were determined. Fig. 7 shows the results which were obtained with the set-up as shown in Fig. 1 and with a plaster test surface having a couple embedded flush with the surface.

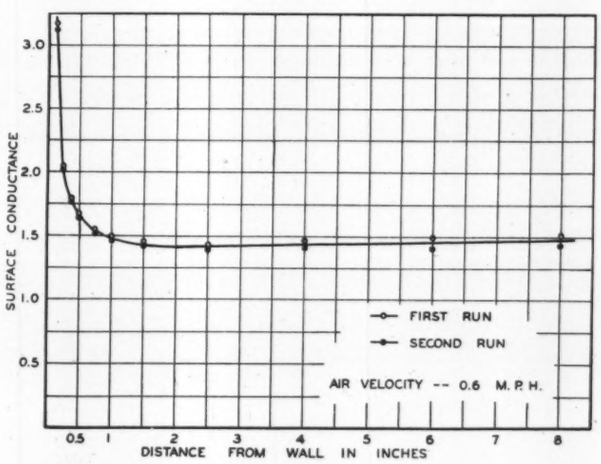

FIG. 6—RELATION BETWEEN SURFACE CONDUCTANCE AND DISTANCE FROM SURFACE AT WHICH AIR TEMPERATURES ARE TAKEN. DETERMINED ON HOT BOX APPARATUS

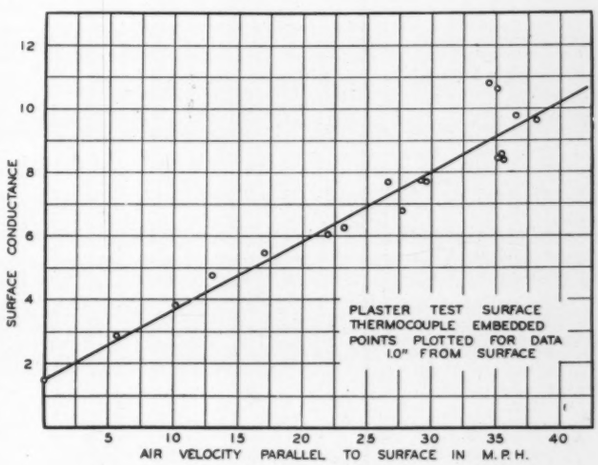

FIG. 7—RELATION BETWEEN SURFACE CONDUCTANCE AND AIR VELOCITY ONE INCH FROM PLASTER SURFACE AND 70 DEG. FAHR. MEAN TEMPERATURE. THERMOCOUPLE EMBEDDED IN SURFACE

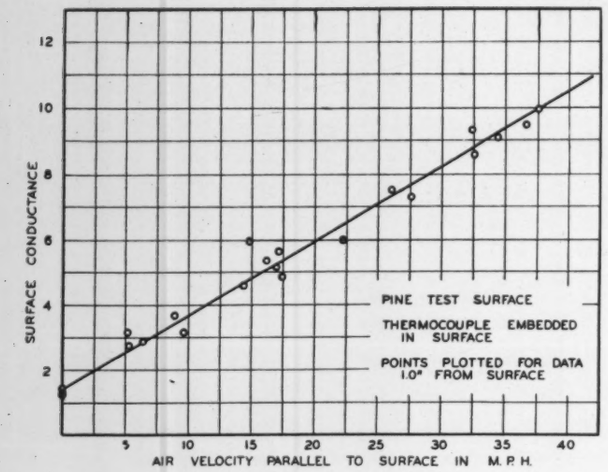
SURFACE CONDUCTANCE
AIR VELOCITY PARALLEL TO SURFACE IN M. P. H.
PINE TEST SURFACE
THERMOCOUPLE EMBEDDED IN SURFACE
POINTS PLOTTED FOR DATA 1.0" FROM SURFACE

FIG. 8—RELATION BETWEEN SURFACE CONDUCTANCE AND AIR VELOCITY ONE INCH FROM PINE TEST SURFACE. SEVENTY DEG. FAHR. MEAN TEMPERATURE

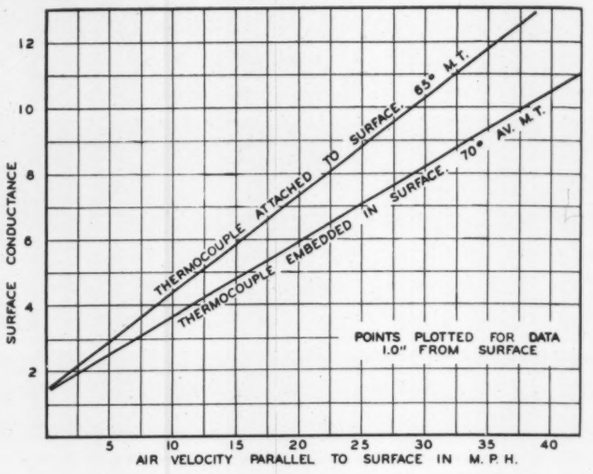
SURFACE CONDUCTANCE
AIR VELOCITY PARALLEL TO SURFACE IN M. P. H.
THERMOCOUPLE ATTACHED TO SURFACE, 65° M.T.
THERMOCOUPLE EMBEDDED IN SURFACE, 70° AV. M.T.
POINTS PLOTTED FOR DATA 1.0" FROM SURFACE

FIG. 9—PINE TEST SURFACE. THERMOCOUPLES ATTACHED TO THE SURFACE AND EMBEDDED FLUSH WITH THE SURFACE

In this set-up it was difficult to maintain accurately any given mean temperature. Therefore, the mean temperatures for this set of tests varied from 70 deg. fahr. by plus or minus 10 deg. The points, however, are sufficiently close to establish a straight line relation between air velocity and surface conductance. Fig. 8 shows the results as obtained for a pine test surface with a thermocouple embedded and tested with the same apparatus and at the same maintained mean temperature as for Fig. 7. From the curves of Figs. 7 and 8, it is apparent that there is but very little difference between plaster and pine surfaces, although this cannot be taken as final on account of the variation between the mean temperatures. As previously stated, the lack of definite temperature control in the first set-up led to a second arrangement by which air was supplied from a refrigerator room. The air from this room was controlled thermostatically to plus or minus 1 deg. fahr. With this apparatus, tests were made with a thermocouple attached to a pine surface and covered with thin vellum paper. For this test the surface and air temperatures were controlled so as to maintain a constant mean temperature between the air and surface of 65 deg. fahr.

The surface coefficients for this test are shown by the upper curve of Fig. 9. The lower curve is a duplicate of Fig. 8, and, while the average mean temperature for this curve is about 5 deg. higher than for the upper curve, it shows a rather definite difference between the coefficients as obtained with thermocouples fastened on with vellum paper and those embedded in the material flush with the surface.

With the work thus far finished, there seems to be but very little difference between the coefficients obtained for the different types of surfaces. The effects of color of surrounding surfaces have been tried to some extent. Black, gray, and galvanized iron all gave the same results; therefore, a dull gray was chosen for the metal surfaces surrounding the test surfaces.

While the test apparatus as set up gave very uniform results, it was felt that the meter could be improved. This is, therefore, being rebuilt and the series of tests will be continued to cover other types of surfaces and a wider range of mean temperatures and air velocities. From tests completed, there appears to be some increase in the coefficient with an increase in mean temperatures. This difference is, however, small, and the amount has not been definitely determined for all ranges of temperatures; it will therefore be reported later.

For air velocities ranging from 0 to 35 miles per hour, the coefficients have followed a straight line relation. This line has been steeper for cases in which the couple has been attached to the surface than when it has been embedded. This difference has been due to the fact that the recorded surface temperatures were more nearly equal to the air temperatures when the couples were placed on the surface; therefore, the apparent surface coefficient was higher.

For practical calculations, the upper curve of Fig. 9 may reasonably be used. It will be noted that this crosses the zero air velocity line at a surface constant of 1.34 which agrees with that obtained by Willard and Lichty at the University of Illinois some years ago, and now used in THE GUIDE. The coefficient at 15 miles is, however, somewhat higher. With the construction of a new meter, this work is to be continued, and further reports will be made through the JOURNAL of the AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS.

Tests on Oil Burners for Domestic Heating

A Study of the Oil Burner as Applied to Domestic Heating, is the title of a publication issued by the U. S. Department of Agriculture as Technical Bulletin 109-T. This bulletin gives the results of a series of tests made with several types of burners supplemented by a study of many domestic installations and indicates the performance that may be expected from these burners, the adaptability of existing heating plants to oil burning and the cost of operating such plants.

A study was also made of oil fuels used for domestic heating and the bulletin gives some information regarding oil fuel specifications and the relative merits of different grades of fuel oils.

Absorption of Solar Radiation in Its Relation to the Temperature, Color, Angle and Other Characteristics of the Absorbing Surface

By F. C. Houghten[1] and Carl Gutberlet[2], Pittsburgh, Pa.
MEMBERS

ABSORPTION of solar radiation by buildings is daily becoming of greater importance to the heating and air conditioning engineer. Increase in the application of cooling to buildings in summer is an important factor in this growth of interest. The application of more scientific methods and closer calculation to the estimation of the heating requirements of buildings is also, however, an important factor in the growing interest in this question. With more scientific air conditioning, the relative effect of heat from the sun on heating requirements and proper temperature distribution indoors becomes more noticeable.

The rate of transmission of energy through space from the sun, like the true temperature of the sun, was long a question of controversy among astronomers and physicists. In recent years, however, a close agreement has been reached on both of these values.

According to Bigelow,[3] the radiating isothermal layer or the photosphere of the sun has a temperature of 7,655 deg. cent., and emits black body radiation. The radiation leaving this layer would give 5.58 calories per minute per square meter (1295 B.t.u. per sq. ft. per hr.) of surface normal to the direction of radiation figured at sea level of the earth. Due to absorption of a part of this energy, while passing through the sun's photosphere, the total radiation of 5.58 calories per square meter per minute figured at sea level is reduced to 3.98 calories figured the same way. Of the 3.98 calories per square meter per minute (880 B.t.u. per sq. ft. per hr.) effective at sea level which are received by the extreme outer region of the earth's atmosphere, 2.03 calories are absorbed in passing through to the earth, and only 1.50 calories per sq. meter per minute (332 B.t.u. per sq. ft. per hr.) are actually received at sea level on a clear day. Smoke, haze, fog, and cloudy weather tend to reduce this figure. Determination of the intensity of the sun's radiation at different altitudes gives a total radiation of 2.138 calories per square meter per minute (471 B.t.u. per sq. ft. per hr.), at the top of Mt. Whitney 4420 meters (14,501 ft.) above sea level; 1.771 calories (394 B.t.u.), at the top of Mt. Wilson, 1780 meters (5839 ft.) above sea level; 1.529 calories (338 B.t.u.), at Washington, 34 meters (111 ft.) above sea level; and 1.525 calories (337 B.t.u.) at sea level. Although the total rate of heat transmission through our atmosphere as given above is accurately known, these data are of little or no value in determining the rate of heat absorption by buildings.

In order to establish data on this subject, the Research Laboratory recently made a study[4] of the heat passing through certain types of roof construction and the temperature attained by the roof on hot summer days. These observations were made incidental to a general laboratory study of heat transmission through building construction, and no attempt was made to control any of the factors governing the heat transfer. As the sun's radiation falling upon the roof increased in intensity throughout the day, the temperature of the roof rose to a maximum and then receded. In some cases, a high temperature of 140 deg. fahr. was reached. As a result of this study, data were not made available on the rate of heat absorption by a surface for any given temperature conditions.

For a complete understanding of the subject of heat absorption by walls, data should be available giving the rate of absorption by a number of different surfaces for various temperatures of the surface and the air in contact with it. Fig. 1 shows, diagrammatically, what happens when the sun's rays impinge upon the roof or wall surface *XY*. *A* represents the total radiant energy impinging against the surface.

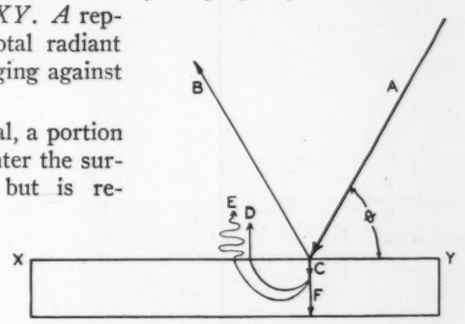

FIG. 1—DISTRIBUTION OF ENERGY OF SUN'S RADIATION UPON STRIKING A SURFACE *XY*
A—TOTAL RADIATION. *B*—REFLECTED RADIATION. *C*—TOTAL ABSORPTION BY SURFACE. *D*—RE-RADIATION FROM THE SURFACE. *E*—CONVECTION LOSS FROM THE SURFACE. *F*—RESULTING HEAT STORAGE IN WALL OR MADE AVAILABLE FOR TRANSMISSION FROM OPPOSITE SIDE

Of this total, a portion *B* does not enter the surface at all, but is reflected away from the structure and need not be considered further. The amount of such reflection depends upon the angle θ, the polish of the surface, and the material of which it is made. In general, metallic surfaces reflect a large portion of the energy rays while such materials as are usually used in building construction, including all but metallic paints,

[1] Director, Research Laboratory, AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS, Pittsburgh, Pa.

[2] Research Physicist, Research Laboratory, AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS.

[3] Treatise on the Sun's Radiation, by Bigelow, John Wiley & Sons.

For presentation at the 36th Annual Meeting of the AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS, Philadelphia, Pa., January, 1930.

[4] Heat Transfer Through a Roof Under Summer Conditions—F. C. Houghten and C. G. F. Zobel, JOURNAL AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS, August, 1928.

are assumed to reflect a comparatively small portion of the total radiant energy.

The part of the total radiation A which is not reflected away from the surface may be represented by C. Upon entering the surface the energy changes from radiant energy such as light to heat, and is manifest by a rise in temperature of the material. Due to the rise in temperature of the structure as a result of absorption of the energy C, the roof surface XY becomes an independent radiator sending radiant energy represented by D, back into space—D depending upon the character of the surface XY and the fourth power of its absolute temperature. Another portion, E, of the heat is lost from the surface XY by convection currents of air. E depends upon the temperature of the air and the surface XY, and the velocity of air currents over the surface. The remaining portion of the energy now in the form of heat remains in the structure raising its temperature or is carried away from the opposite surface. It may be represented by F.

When we consider all the above phenomena taking place at the same time with different degrees of intensity it is seen that the problem is complicated, and that perhaps the best fundamental data available would be the heat F not given back to space or the air on the side of the wall from which the radiation comes. This depends upon the intensity of the original radiation A, the reflected portion B, which depends upon the angle θ and the reflecting properties of the surface, the independent radiation from the surface, which depends upon the emissivity of the surface and fourth power of the absolute temperature of the surface, the convection loss E, which depends upon air velocity over the surface XY and the temperatures of the surface and air. Of these factors the temperature of the surface XY and the temperature of the air in contact with it, are perhaps the most important variables and the data obtained in this investigation were collected with a view of establishing the relationship between F and these temperatures for various types of surfaces. Data are also given on the relation of energy absorption to the angle θ between the direction of the radiation and the plane of the surface, and on the effect of an intervening sheet of glass between the surface and the sun.

Fig. 2 is a drawing, and Fig. 3 a photograph of the apparatus used for collecting the data. The apparatus consisted essentially of a two-foot square surface D, made by waxing black oilcloth to a 1/16 in. thick Nicholls heat meter E, which in turn was waxed to the copper water cooler F. The opposite side of the cooler was insulated by 1 in. of hair felt and 2 in. of cork board. This arrangement made a wall unit 2 ft. square by about 5 in. thick which was supported by horizontal and vertical pivots, so that the plane surface studied could be placed at any angle with the direction of the sun's radiation. A skeleton framework was arranged so that a 3 ft. square plate of double strength window glass, 1/8 in. thick, could be placed symmetrically between the surface and the sun and 6 in. from the surface. The same skeleton frame work held a paper shield designed to protect the surface studied from wind but not to interfere any more than necessary with natural convection currents. This paper shield in no way shaded the surface studied from the sun's rays.

In order to keep (throughout the test) the desired angle between the plane of the surface studied and

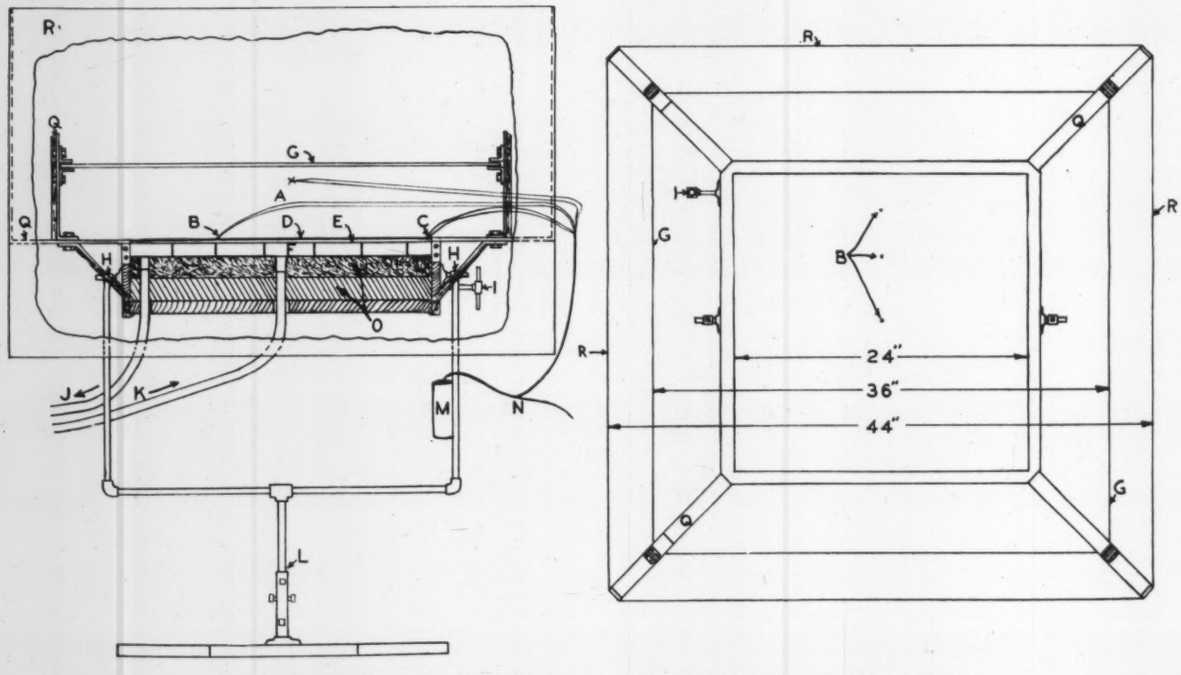

Fig. 2—Set Up for Measuring Rate of Heat Absorption from the Sun

A—Air Temperature Thermocouple. *B*—Surface Temperature Thermocouple. *C*—Heat Meter Leads. *D*—Surface Studied. *E*—Heat Meter. *F*—Water Cooled Plate. *G*—Glass. *H*—Horizontal Pivot. *I*—Sight for Adjusting Angle of Surface. *J*—Water to Circulating Pump and Tank. *K*—Water from Circulating Pump and Tank. *L*—Vertical Pivot. *M*—Cold Junction Bottle. *N*—Cable to Potentiometer. *O*—Insulation, Hair Felt and Cork Board. *P*—Sun Dial. *Q*—Frame for Supporting Paper Shield and Glass. *R*—Paper Shield

the direction of the sun, a piece of ½-in. pipe, 14 in. long was fastened to the wall edge so that its angle with the surface could be set at any desired value; thus when the sun shone straight through this pipe on to a screen below, the surface was in the proper position.

The tests were made on a flat roof of a garage building of the U. S. Bureau of Mines, Pittsburgh Station. This location gave a clear view of the sun from 7:30 a.m. until 6:30 p.m. An insulated and water-proof cable carried the leads from the surface and air thermocouples, and from the heat meter to a potentiometer set-up located in an observation room below. Water, the temperature of which was controlled, was circulated through the cooler in the wall by an electrically driven pump located in this same observation room.

In making a test the desired angle between the surface and the sun's radiation was maintained and water of the proper temperature was circulated through the cooler to give the desired surface temperature. These conditions were maintained while frequent observations were made of the rate of heat flow through the meter and of the surface and air temperatures.

TABLE 1—ABSORPTION OF SOLAR RADIATION BY BLACK OILCLOTH SURFACE AT DIFFERENT TEMPERATURES AND DISSIPATION OF HEAT FROM THIS SAME SURFACE TO THE AIR IN CONTACT WITH IT

TIME	B.T.U. PER SQ. FT. PER HOUR ABSORBED	SURFACE TEMP.	AIR TEMP. DEG. F.	HEAT DISSIPATED FROM SURF. TO AIR	CORRECTED HEAT ABSORP.	B.T.U. PER SQ. FT. PER HOUR ABSORBED	SURFACE TEMP.	AIR TEMP.	HEAT DISSIPATED FROM AIR TO SURF.	CORRECTED HEAT ABSORPTION
	F	t_1	t_2	$D+E$	C	F	t_1	t_2	$D+E$	C
Aug. 15 10:10 a. m.	128	54.2	60.0	-11.6	116.4	.....	.....	.....	.....	.....
Aug. 15 1:50 p. m.	194	63.0	62.0	2.0	196.0	.....	.....	.....	.....	.....
Aug. 19 9:45 a. m.	155	71.2	66	10.4	165.4	.....	.....	.....	.....	.....
Aug. 19 11:25 a. m.	215	73.2	68	10.4	225.4	.....	.....	.....	.....	.....
Aug. 20 11:30 a. m.	244	72.5	66	13	257	.....	.....	.....	.....	.....
Aug. 20 12:40 a. m.	280	72.5	76	-7	273	209	102	76	52	261
Aug. 21 11:00 a. m.	175	81	67	28	203	.....	.....	.....	.....	.....
Aug. 21 2:10 p. m.	160	80.5	79.5	28	162	115	100.5	79.5	42	157
Aug. 26* 1 p. m.	37	70	80	-20	17	.....	.....	.....	.....	.....
Aug. 26 2:40 p. m.	175	70	85	-30	145	140	86	85	2	142
Aug. 26 4:10 p. m.	200	70	84	-28	172	.....	.....	.....	.....	.....
Sept. 3 10:00 a. m.	72	100	72	56	128	111	80	72	16	127
Sept. 3 12:13 a. m.	159	100	80	40	199	198	80	80	0	198
Sept. 3 3 p. m.	200	100	86	28	228	237	80	86	-12	225
Sept. 3 5:40 p. m.	128	100	85.4	29.2	157.2	171	80	85.4	10.8	160.2

For F, D, E, see Fig. 1.
$C = F + (D + E)$
$= F + 2\,(t - t_2)$

* Hazy, sun barely visible.

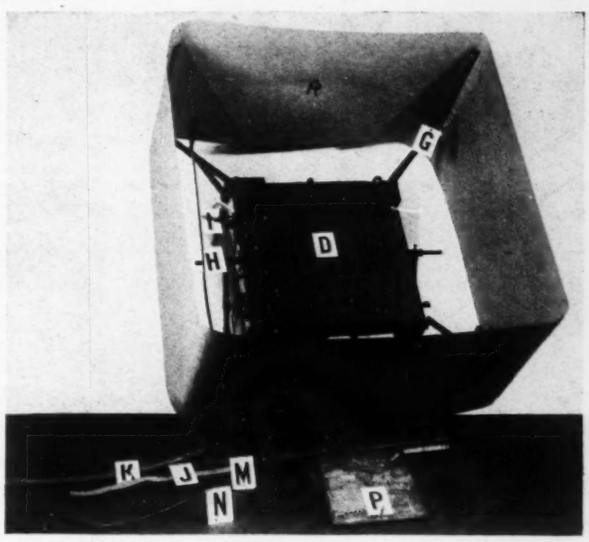

FIG. 3—SET UP FOR MEASURING RATE OF HEAT ABSORPTION FROM THE SUN. LETTERS ARE THE SAME AS THE REFERENCES ON FIG. 2

In comparing the relative absorption of the surface for two different conditions of temperature, color, angle, or with intervening glass, tests were made alternately on the two conditions. The thermal resistance between the surface and the water of the cooler was so small that equilibrium of heat flow with any temperature condition usually could be reached in 10 minutes. Sufficient data on any given condition were always collected to show a steady rate of heat flow for at least ½ hour.

The greatest difficulty was experienced in determining the relative absorption with the different painted surfaces. The paints were made by mixing lamp black, red brick dust, and aluminum bronzing dust with absolute alcohol containing just sufficient shellac to keep the powder from blowing off after it was dry. This paint was found to become apparently dry in four minutes, and satisfactory data could be collected from 10 to 20 minutes after this time.

Obviously, but one direct comparison could be obtained between the oilcloth and any paint without changing the oilcloth. By adding one paint over the other several alternate comparisons were made between the lamp black and the red and the aluminum painted surface. Each such application of paint added a slight error due to the fact that the measured temperature was not the true temperature of the surface, but no difference in results because of this factor was noticed.

The effect of temperature of the absorbing surface on heat absorption for the prevailing air temperature on September 3, 1929 is shown in Fig. 4. Similar data for other days are given in Table 1. The points in the solid line portions of each curve represent the measured rate of heat absorption by the surface for the respective surface temperatures. The solid and broken line curves at the top of the chart give respectively the air temperature as measured in a shaded location near the surface studied and as reported by the Pittsburgh Station of the U. S. Weather Bureau about four miles away. It will be noted from the solid line portions of the heat absorption curves that alternate tests covering about

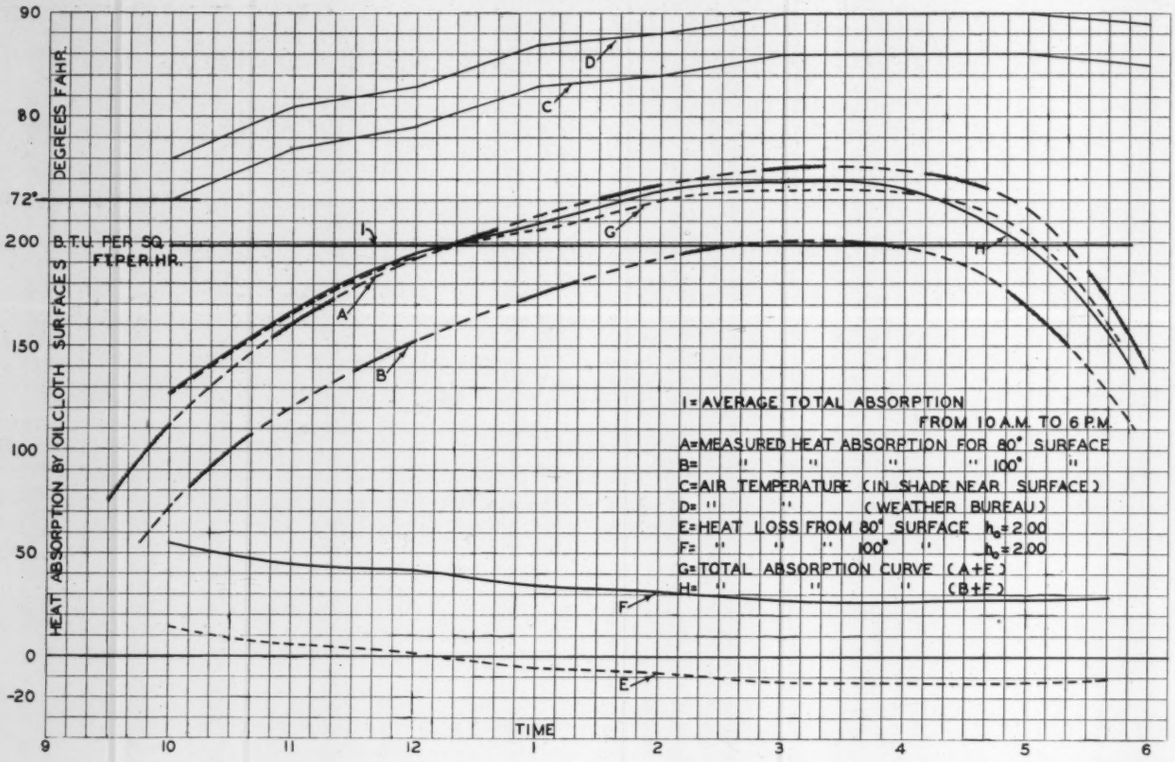
DEGREES FAHR.
B.T.U. PER SQ. FT. PER HR.
HEAT ABSORPTION BY OILCLOTH SURFACES
TIME
I = AVERAGE TOTAL ABSORPTION FROM 10 A.M. TO 6 P.M.
A = MEASURED HEAT ABSORPTION FOR 80° SURFACE
B = " " " " 100° "
C = AIR TEMPERATURE (IN SHADE NEAR SURFACE)
D = " " (WEATHER BUREAU)
E = HEAT LOSS FROM 80° SURFACE h_o = 2.00
F = " " " 100° " h_o = 2.00
G = TOTAL ABSORPTION CURVE (A+E)
H = " " " (B+F)

FIG. 4—HEAT ABSORPTION OF SOLAR RADIATION AND DISSIPATION OF HEAT BY A BLACK OILCLOTH SURFACE AT 80 DEG. AND 100 DEG. FAHR.

½ hour were made on the two conditions with 10 minutes or more intervening, which was the time required for bringing the heat flow into equilibrium with the changed temperature conditions.

It will be noted from the air temperature curve C that until 12:13 the air temperature was colder than either of the surface temperatures studied. Later in the day the air temperature went up to 86 deg. and then remained practically constant. As a result both surfaces were necessarily giving off heat to the air and space until 12:13 noon. At 12:13, the temperature of the 80 deg. surface and of the air became the same, and hence no heat was given back to the air by the surface, and necessarily the determination by the meter equaled the total absorption from the sun. After 12:13 the 80 deg. surface was cooler than the air and hence it gained heat not only by radiation from the sun but from the air as well.

Considering the small air currents over the surface studied, a surface transmission coefficient $H_o = 2.0$ for the surface studied to the air, or vice versa, may be assumed as reasonable, although we have no accurate data on which to base it. Curves E and F give the rate of heat exchange between the surface at 80 deg. and 100 deg. respectively and the air during the period of test. This rate was calculated by the formula $H = h_o (t_s - t_a)$

where H = the rate of heat loss from the surface in B.t.u. per sq. ft. per hr.
h_o = the surface conductance coefficient assumed equal to 2.0
t_s = surface temperature
t_a = air temperature.

Curves E and F, Fig. 4 are represented by D and F (Fig. 1), combined for the two surface temperatures, while curves A and B (Fig. 4), for the two temperature conditions are represented by F, Fig. 1. It will be noted that the total absorption of radiant energy from the sun by the surface is equal to DE and F (Fig. 1) combined. Hence the heat transfer indicated by $A + E$ and $B + F$ respectively should represent the total heat absorbed by the surface. Curves G and H are respectively the algebraic sum of curves $A + E$ and $B + F$. As should be expected G and H coincide fairly well throughout the period of the tests. Curve I gives the average total rate of heat absorption for the period 10 a. m. to 6 p. m.

Table 1 gives the measured heat absorption and the corrected heat absorption for various temperatures and

TABLE 2—RELATIVE HEAT ABSORPTION BY DIFFERENT SURFACES

Date and Time	Kind of Surface	Surf. Temp. Deg. F.	Air Temp. Deg. F.	Heat Absorp. B.t.u./ Sq.Ft./ Hour	Kind of surface	Surf. Temp. Deg. F.	Air Temp. Deg. F.	Heat Absorption	Heat Absorp per cent. of Blk. Oil Cloth
Sept. 20 11:40 a. m.	black oil cloth	80	58	182	Lamp black paint	80	58	171	% 94
Sept. 20 1:30 p. m.	Lamp black paint	80	62.3	207	Red paint	80	62.3	143	64.9
Sept. 20 2:50 p. m.	Lamp black paint	80	64.1	203	Red paint	80	64.1	137	63.4
Sept. 20 3:40 p. m.	Lamp black paint	80	65	182	Red paint	80	65	120	62
Sept. 10 12:55 p. m.	Black oil cloth	80	77	256	Aluminum paint	80	77	73	28.5
Sept. 10 2:10 p.m.	Black oil cloth	80	79	222	Aluminum paint	80	79	62	27.9

times. It will be noted that for days on which tests were made the maximum corrected absorption was 273 B.t.u. per square feet per hour.

The relative rate of absorption of solar energy for black oilcloth, lamp black and red painted surfaces is given in Fig. 5. The effect of inserting a single pane of double strength glass about 6 in. above the surface through which the sun's rays had to pass is also shown.

Table 2 gives results of other tests on the effect of heat absorption by different surfaces, while Table 3 gives the results of tests on the effect of glass in reducing the rate of heat absorption.

In considering the effect of the glass on heat absorption a number of factors must be taken into consideration. As the sun's rays impinge against, and pass through, an intervening sheet of glass some radiation is reflected directly from each of the two glass surfaces, and additional heat is absorbed in passing through the glass, the amount depending upon the character of the glass and its thickness. All of the heat reflected by the glass surfaces and most of that absorbed within the glass is no longer available to reach the surface studied and hence the heat absorption by the surface must be reduced by this amount. At the same time the glass necessarily affects air circulation next to the surface studied, probably reducing it, and also probably effecting a rise in temperature of the air next to the surface. Hence one may assume that the glass decreased the heat given back to the air by the surface studied, or increased the flow when it was in the opposite direction. For this reason the glass would tend to decrease the heat given back to the air by the surface or to increase the apparent absorption. If this is correct the apparent decrease of approximately 10 per cent in absorption by the surface with intervening glass does not represent all the heat intercepted. However, it is doubtful if this factor is very large.

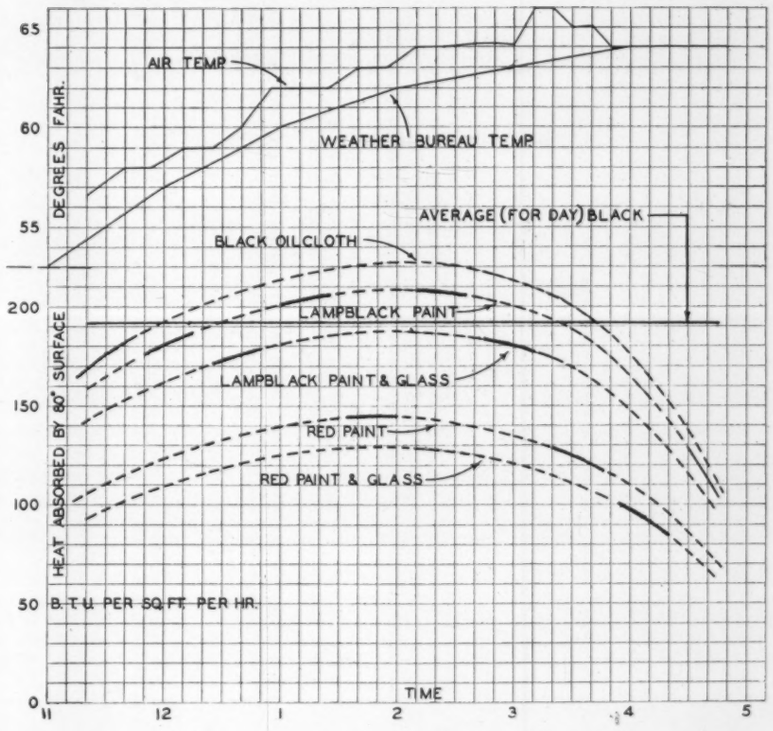

FIG. 5—ABSORPTION OF SOLAR RADIATION BY OILCLOTH AND PAINTED SURFACES WITH AND WITHOUT INTERVENING GLASS

In this connection it is of interest to review some values for absorption of solar energy by glass reported by the U. S. Bureau of Standards. These data were collected in a study of the effectiveness of glass used in goggles for protecting acetylene and arc-welders' eyes while at work. The Bureau of Standards values are given in Table 4.

It will be noted from Table 3 that the reduction in absorption of heat by the surfaces studied due to the intervening glass becomes greater as the angle between the surface and direction of impingement falls below 90 deg. This should be expected since the smaller the angle θ, or the greater the angle of incidence, the greater the reflection from the glass surface.

The effect of angle of incidence on the absorption of radiant energy is two fold. The larger the angle of incidence or the smaller the angle between the direction of radiation and the surface, the greater the reflection B, Fig. 1. For non-reflecting surfaces, however, this factor probably is not very important. More important is the fact that the smaller the angle between the rays and the surface, the lower the intensity of impingement of radiation per unit area of surface. This is purely a geometrical factor and the intensity of impingement per unit of area on any surface is given by $Q = H \sin \theta$ where Q is intensity of radiation falling on the given surface at an angle of θ with the surface, and H is the intensity of radiation on the same surface normal to the direction of radiation.

TABLE 3—EFFECT OF PANE OF DOUBLE STRENGTH (⅛" THICK) GLASS IN ABSORBING RADIANT ENERGY PASSING THROUGH IT

DATE	TIME	KIND OF SURFACE	ANGLE	SURF. TEMP. DEG. F.	AIR TEMP. DEG. F.	HEAT ABSORP. WITHOUT GLASS	HEAT ABSORP. WITH GLASS	PER CENT HEAT ABSORBED BY GLASS
								%
Sept. 15	12:45 a. m.	Black oil cloth	90	80	85	133	120	9.8
Sept. 5	2:35 p. m.	Black oil cloth	90	80	90	146	133	8.9
Sept. 5	4:05 p. m.	Black oil cloth	66	80	90	107	96	10.3
Sept. 5	1:45 p. m.	Black oil cloth	57	80	88	136	117	13.8
Sept. 5	3:05 p. m.	Black oil cloth	50	80	90	109	91	16.5
Sept. 5	1:15 p. m.	Black oil cloth	43	80	88	98	82	16.2
Sept. 20	12:30 a. m.	Lamp black paint	90	80	59.3	192	172	10.5
Sept. 20	2:50 p. m.	Lamp black paint	90	80	64.1	203	182	10.5
Sept. 20	4:00 p. m.	Red paint	90	80	64.0	110	98	11

TABLE 4—ABSORPTION OF SOLAR RADIATION BY VARIOUS KINDS OF GLASS USED IN GOGGLES AS DETERMINED BY THE U. S. BUREAU OF STANDARDS[1]

COLOR	TRADE NAME	THICKNESS IN MM.	TRANSMISSION PER CENT OF TOTAL SOLAR RADIATION
Greenish yellow		2.04	63
Yellow green		2.14	9
Amber		5.57	43
Orange		3.57	47
Sage green		1.95	17
Black	Smoke, C.	2.26	60
Neutral tint	Crookes, A.	1.97	89
Colorless		1.58	88
Amethyst		2.11	79
Blue-purple		3.13	41
RED		2.90	48
Colorless	Window	1.85	82
Colorless	Crown	1.56	92
Clear	Water		76

[1] Treatise on the Sun's Radiation, by Bigelow, John Wiley and Sons.

The curve (Fig. 6) shows the reduction in heat absorption with the decrease in the angle of incidence. The *x*'s give points for the black oilcloth surface without the intervening glass and the circles give points for tests with the same surface but with the glass intervening. The curve is drawn for values of Q, given by the equation $Q = H$ Sine θ. It is seen that the test points fit the theoretical curve fairly well or in other words for any angle of impingement the formula $Q = H$ Sine θ is apparently the correct form to use for such calculations.

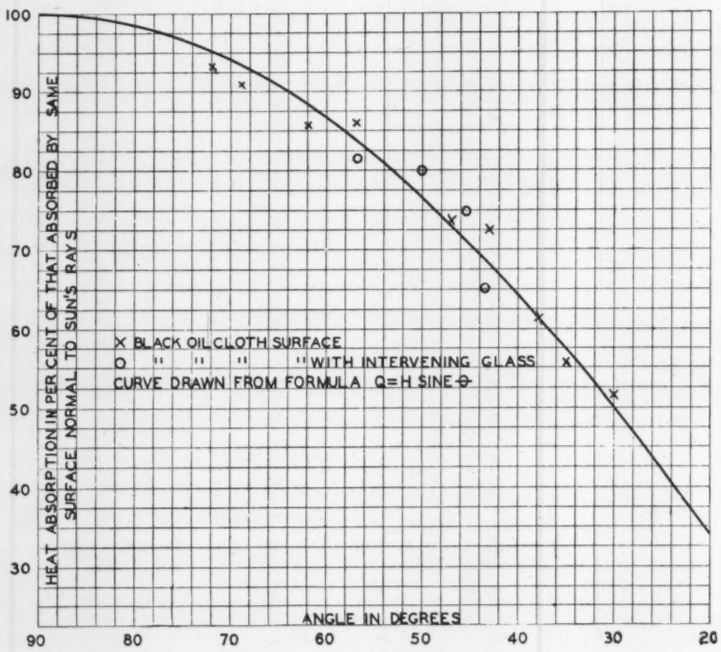

FIG. 6—REDUCTION IN HEAT ABSORPTION DUE TO DECREASE OF ANGLE OF INCIDENCE

The data given shows maximum rates of heat absorption of the sun for different days ranging up to 273 B.t.u. per square foot per hour or up to 1.13 square feet of equivalent steam radiation per square foot. According to Bigelow, the total energy emission from the sun measured at sea level on the earth is about 332 B.t.u. per square foot per hour or 1.38 square feet of equivalent steam radiation per square foot. This difference can be credited to reflection from the surface studied and lower total radiation from the sun due to smoke and haze while the tests were being made. The tests reported were made on days that would normally be considered quite bright in Pittsburgh. However, the intensity of radiation was probably considerably less than would be found in other places such as Washington or at the sea coast.

Summary and Conclusions

1. The total energy emitted by the sun figured normal to the direction of radiation at sea level is given by Bigelow as about 332 B.t.u. per square foot per hour or 1.38 square feet of equivalent steam radiation on a clear day.

2. The heat absorption by a black oilcloth surface perpendicular to the sun's radiation was found to be as high as 273 B.t.u. per square foot per hour on a day which would be considered bright in the city of Pittsburgh.

3. Lamp black painted surfaces, red brick dust painted surfaces and aluminum bronze painted surfaces perpendicular to the sun's radiation show 94.0, 63.4, and 28.2 per cent as high a rate of absorption as the black oilcloth.

4. The difference in retention of absorbed heat by surfaces having temperatures different from the air in contact with them apparently can be satisfactorily corrected for a black surface by assuming a surface transmission coefficient of 2.0 B.t.u. per square foot per hour per deg. temperature difference between the surface and air, when this temperature difference is not greater than 20 deg.

5. A single pane of double strength window glass placed so that the sun's rays must pass through it before it impinges on the surface reduces the heat absorption of that surface by from 8.9 to 16.5 per cent, when the impingement is normal. For smaller angles of impingement the glass retards a greater per cent of the radiant energy.

6. The rate of absorption of heat from the sun's radiation by a surface at any angle with the direction of radiation may be satisfactorily computed by the equation $Q = H$ Sine θ where Q is rate of absorption for the angle θ and H is the rate of absorption for the same surface normal to the direction of radiation.

World Power Conference

The engineering profession and the power developing and using industries of the United States are planning an elaborate papers program for discussion in the sessions of the World Power Conference to be held in Berlin, June 16-25, 1930.

The American Committee has formulated the program and it is expected that General Reports of all the papers will be available in French, German and English.

Friction Losses and Observed Static Pressures in a Domestic Fan Furnace Heating System

By A. C. Willard[1] and A. P. Kratz[2], Urbana, Ill.
MEMBERS

Acknowledgments

THE data presented in this paper were obtained in connection with an investigation which is being conducted by the Engineering Experiment Station of the University of Illinois, of which M. S. Ketchum, Dean of the College of Engineering, is Director, in co-operation with the *National Warm Air Heating Association*. This paper constitutes part of a more complete report on the further investigation of warm-air furnaces and heating systems which will appear as a future bulletin of the Engineering Experiment Station in the furnace heating series. Much of the actual experimental work involved in this study of fans as carried out in the Research Residence plant was performed by J. F. Quereau, formerly Special Research Assistant attached to this investigation.

Under the terms of a co-operative agreement between the *National Warm Air Heating Association* and the University of Illinois, a very extensive study of furnace heating problems has been made, using first an experimental plant with auxiliary equipment in the laboratory, and later a typical modern residence erected by the association for the express purpose of correlating and extending the work in the laboratory to the conditions of actual installation. It was in this residence that the data herein presented were obtained.

Introduction

The increasing tendency to apply various types of small disc and propeller fans as well as small centrifugal fans to warm-air furnace heating systems of the gravity circulating type has developed without very much attention to the heads or resistances which these fans must overcome. Little consideration has been given to the unusual operating conditions surrounding such a fan installation, since these fans must operate in a more or less rapidly moving current of air created by the gravity or natural circulation of the furnace. The rating of a fan under the usual *still air* conditions *does not apply* when the fan is installed within a duct and in a *moving air* stream of variable velocity and of a volume which is often equal to or even in excess of the fan capacity in *still air*.

As a result of the failure to take account of the peculiar conditions surrounding the installations of fans in domestic furnace heating systems, the following possibilities or situations may arise:

(1) With a well designed gravity circulating system and the usual commercial fan as applied today, the natural circulation of the furnace may practically submerge the fan and the fan may become a drag on the system. This is almost certain to occur at high combustion rates, and with small fans.

(2) With any system designed for gravity circulation the fan will almost invariably unbalance the previous gravity operation of the system, whether good or bad, and tend to increase the flow in those pipes in which there was the least resistance and friction as a gravity system. This means, usually, more air to first floor rooms or to short direct runs; and relatively less air to distant rooms. Such a condition may defeat the objective of the fan installation entirely, as shown in item (3).

(3) Since, as explained in item (2), the more air is certain to go to the favored than to the unfavored rooms, the former will immediately overheat unless the air temperature at the registers to these rooms is reduced. The occupant or the thermostat on the first floor will promptly check the fire and maintain 70 deg. fahr. in the favored rooms with the result that the unfavored rooms may actually drop below 70 deg. fahr. and cool off.

(4) Since both the fan and the natural circulation always take place simultaneously when the furnace is under heat, the resistance which the fan has to overcome is an extremely variable quantity, which *may actually range from a positive to a negative value*. In all cases, it will be extremely small; ranging (with the usual type of propeller fan) in a well designed system from a static pressure in the bottom of the furnace casing of +0.010 in. of water for cold furnace with air at 65 deg. fahr. to —0.008 in. of water for hot furnace with air at 150 deg. fahr. at the registers. The fan tested had a *free air* capacity of 1,400 c.f.m. and actually delivered 950 c.f.m. as installed in the furnace shoe with by-pass dampers closed. Even with a centrifugal fan delivering 1,260 c.f.m. of air, the maximum static pressure in the bottom of the casing was only +0.02 in. of water with cold furnace at 65 deg. fahr. and the minimum $0\pm$ inches with hot furnace at 150 deg. fahr.

(5) The propeller type of fan placed in the return duct develops a greater air handling capacity with the by-pass dampers closed than with them open. In either case, the fan suffers a material reduction in its *free air* handling capacity. The net aspirating effect of such a

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fan in a large return duct with dampers open is of negative value since any induced flow which may occur is much more than counterbalanced by the eddy currents and short circuiting which can and does occur when there are no by-pass dampers. Such fans should, therefore, be installed as is generally customary with automatic by-pass dampers when placed in large return air ducts.

(6) Noise of a more or less noticeable character is almost certain to be transmitted to the occupied rooms of the residence. The occupants are never in doubt as to whether or not the fan is in operation.

In addition to the preceding discussion of pressure effects on the performance of small fans when installed in the return ducts of warm air furnace heating systems, it should be made clear that a fan of proper size may have some beneficial effects on residence heating. For example, provided the furnace is hot and the fire is maintained in normal condition, the starting of the fan will almost instantly increase the heating capacity of the furnace and its efficiency. The increases in the system under consideration were large and, although they decreased rather rapidly within half an hour, some increase persisted even at the end of two hours *provided the same intensity of firing was maintained.*

Typical increases in heating capacity were as follows:

(1) With furnace delivering 18,000 B.t.u. per hour at bonnet and a low fire, starting the fan increased the heating capacity to 33,000 B.t.u. in a minute and a half, with a drop to 27,000 in 30 minutes, which became 24,000 in two hours.

(2) With furnace delivering 62,000 B.t.u. per hour at bonnet and a brisk fire, starting the fan increased the heating capacity to a maximum of 83,000 B.t.u. in a minute and a half, with a drop to 73,000 in 30 minutes, which became 70,000 in two hours.

Since the combustion rate was maintained constant in each case the furnace efficiency was benefited in almost the same degree as the heating capacity of the furnace.

The fact must not be lost sight of that starting a fan will do little good unless there is a residual heat in the furnace itself and an active fire is maintained. Fans should not be depended upon to correct improperly designed or poorly installed gravity circulating furnace heating systems. If the system is already out of balance, the fan may merely aggravate the situation unless the distributing system is readjusted to favor the unfortunate rooms. A properly designed and correctly installed gravity circulating system does not need a fan.

Description of Apparatus

The equipment used for these tests was the heating plant installed in the Warm Air Research Residence, which has been completely described in University of Illinois Engineering Experiment Station Bulletin No. 189.[3] This plant consisted of a 27-in. cast-iron circular-radiator furnace equipped with a 52-in. casing, supplying air to 11 basement warm air pipes having a cross-sectional area of 832 sq. in. When equipped with a single recirculating duct of 854 sq. in. cross-sectional area, this furnace heated the house in zero weather with register

[3] "Investigation of Warm-Air Furnaces and Heating Systems, Part IV, Research Residence," by A. C. Willard, A. P. Kratz, and V. S. Day, Engineering Experiment Station Bulletin No. 189.

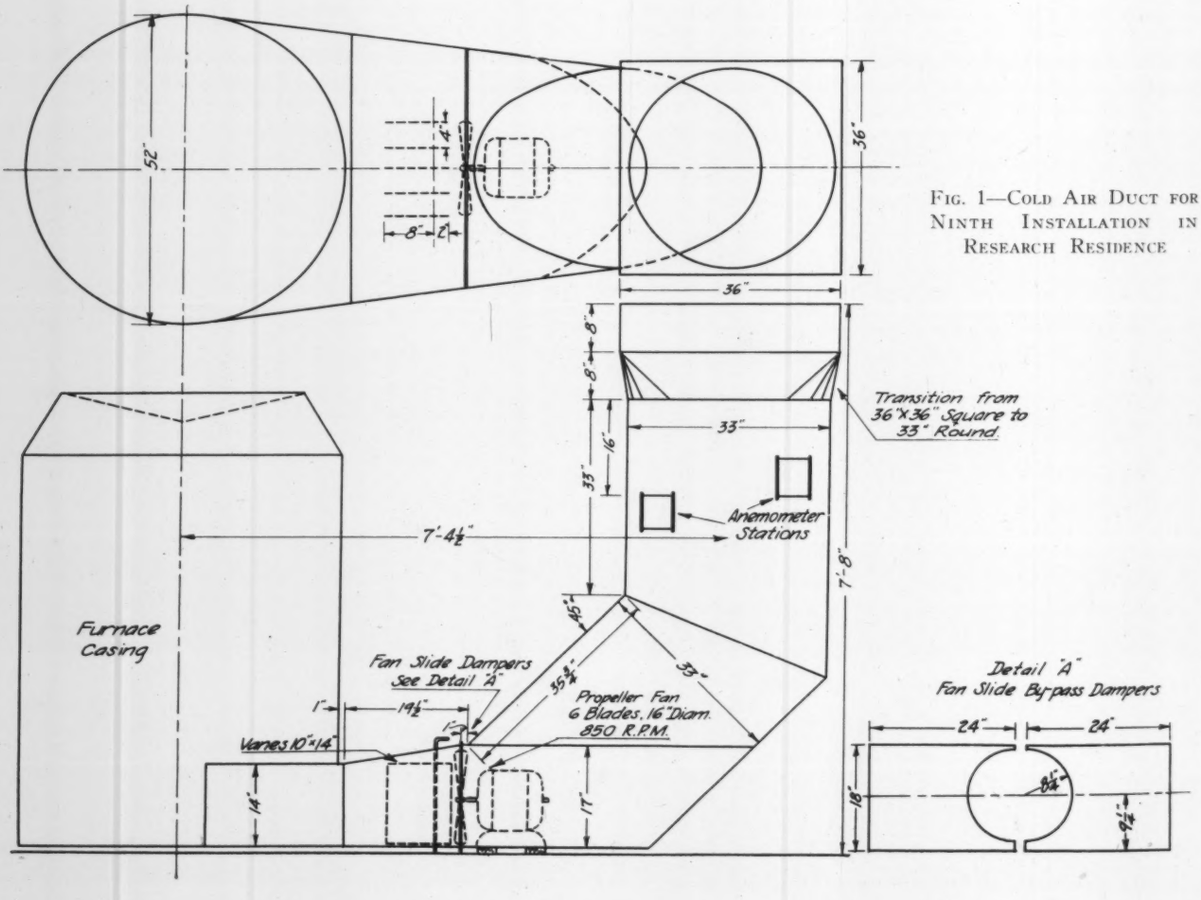
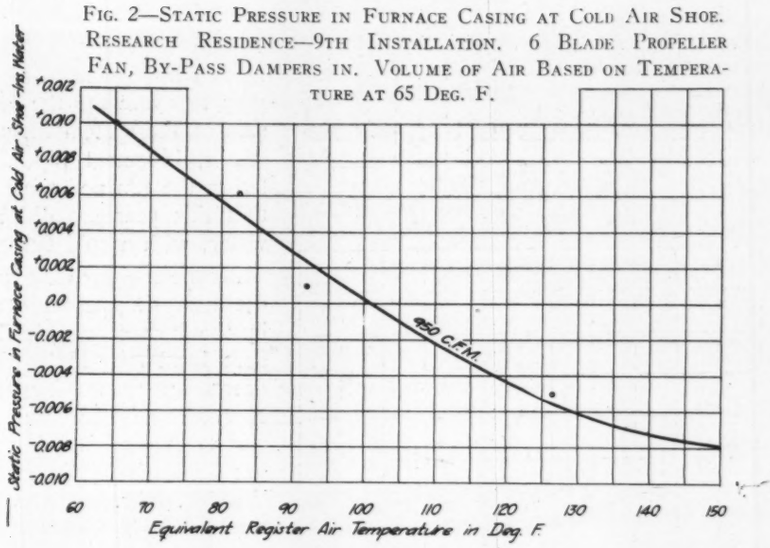


FIG. 1—COLD AIR DUCT FOR NINTH INSTALLATION IN RESEARCH RESIDENCE

FIG. 2—STATIC PRESSURE IN FURNACE CASING AT COLD AIR SHOE. RESEARCH RESIDENCE—9TH INSTALLATION. 6 BLADE PROPELLER FAN, BY-PASS DAMPERS IN. VOLUME OF AIR BASED ON TEMPERATURE AT 65 DEG. F.



air temperatures approximating 135 deg. fahr. Under these conditions practically 680 cu. ft. of air based on 65 deg. fahr. and 29.5 in. of mercury were circulated per minute.

No changes were made in the casing or in the warm air side of the system. Each change in the cold air side of the system has been designated by an installation number, and this discussion is confined to the seventh and ninth installations.

For the seventh installation, the cold air return duct was replaced by a shoe and a diffusion box shown in Fig. 4. The shoe was 12 in. in height and the sides were tangent to the furnace casing. A multiblade centrifugal fan delivered air through a 12-in. round pipe into the side of the diffusion box in such a manner that the velocity of the jet was destroyed, and the air was delivered uniformly across the cross-section of the shoe.

In the ninth installation, a single cold air return duct with a cross-sectional area of 854 sq. in., as in Fig. 1, was used. This duct was connected to a shoe similar to the one used in the seventh installation. A 6-blade propeller fan 16 in. in diameter was installed in the shoe, and slides, or dampers, were provided so that the fan blades revolved in an orifice with a clearance of ¼ in. These dampers are shown in the detail in Fig. 1. When the furnace was operated under gravity flow, the dampers were removed so that the full cross-sectional area of the shoe was effective.

Test Procedure

For the seventh installation the volume of air delivered was measured by means of a Pitot tube placed in the 12-in. round pipe 8.5 ft. from the fan discharge. A 10-point traverse on each of two diameters was used. The angle between the diameters was 90 deg. The static pressures were observed by making a traverse of the shoe with a Pitot tube placed successively in six positions in the cross-section just outside of the line of the furnace casing. The Wahlen gage, or Illinois micromanometer, reading to 0.0005 in. of alcohol was used to measure the pressure. Pressures above atmospheric have been designated as plus and those below atmospheric as minus.

For the ninth installation, the volume of air was measured by means of a calibrated anemometer in the recirculating duct. For this purpose, a traverse was made on two diameters at 90 deg. to each other. Six points

FIG. 3—STATIC PRESSURE AND AIR VOLUME AT COLD AIR SHOE. RESEARCH RESIDENCE, 9TH INSTALLATION. GRAVITY FLOW. TEMPERATURE OF AIR 65 DEG. F.

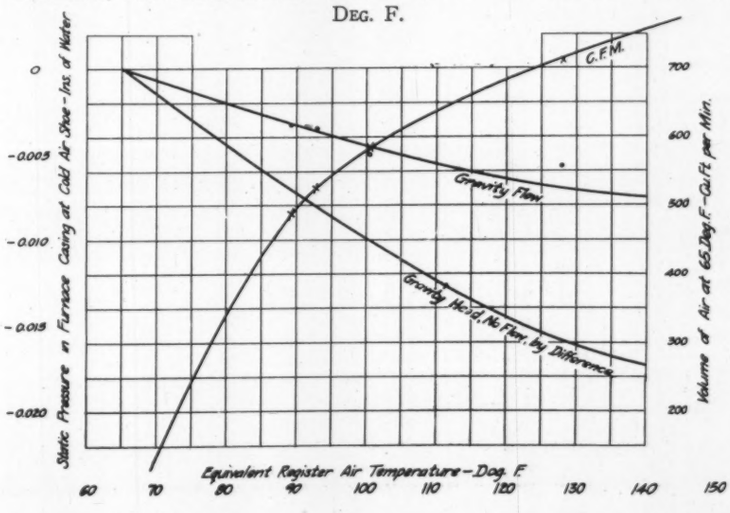
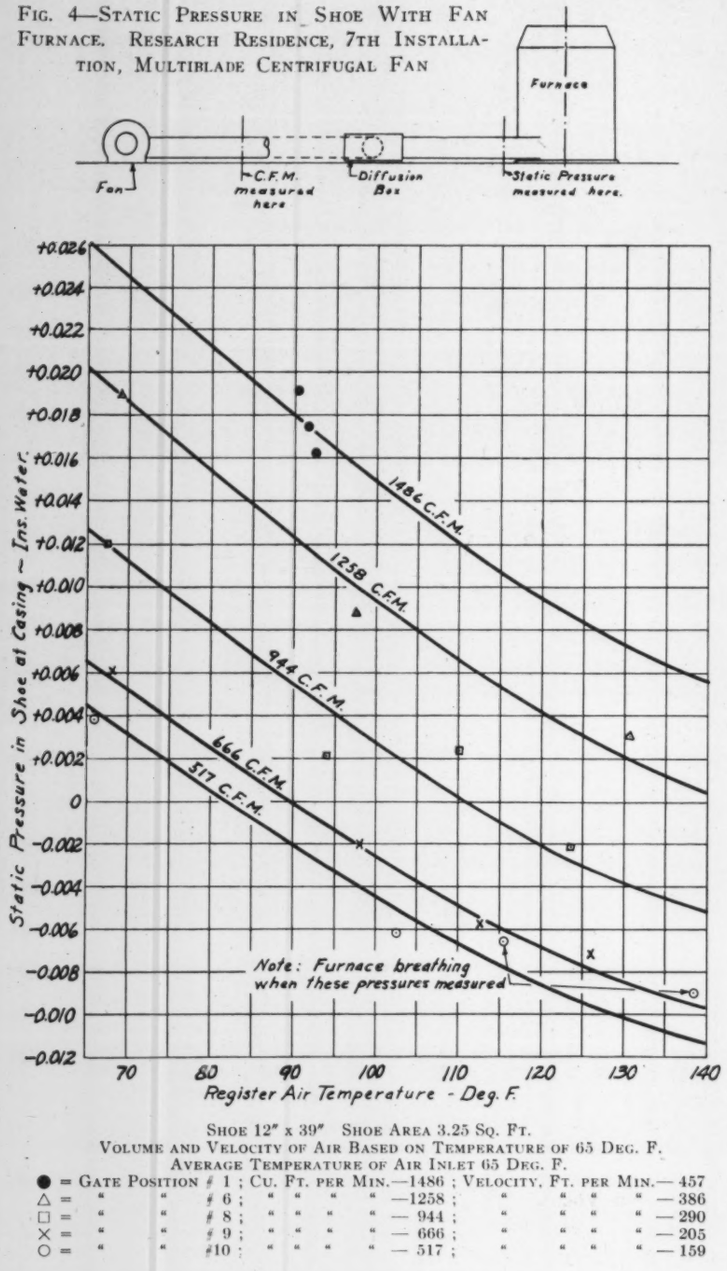


FIG. 4—STATIC PRESSURE IN SHOE WITH FAN FURNACE. RESEARCH RESIDENCE, 7TH INSTALLATION, MULTIBLADE CENTRIFUGAL FAN



SHOE 12" x 39" SHOE AREA 3.25 SQ. FT.
VOLUME AND VELOCITY OF AIR BASED ON TEMPERATURE OF 65 DEG. F.
AVERAGE TEMPERATURE OF AIR INLET 65 DEG. F.

● = GATE POSITION # 1 ; CU. FT. PER MIN.—1486 ; VELOCITY, FT. PER MIN.— 457
△ = " " # 6 ; " " " " —1258 ; " " " " — 386
□ = " " # 8 ; " " " " — 944 ; " " " " — 290
× = " " # 9 ; " " " " — 666 ; " " " " — 205
○ = " " #10 ; " " " " — 517 ; " " " " — 159

were used on each diameter. Since considerable jet action was found in the shoe itself, indicating that the shoe did not *run full*, the static pressures in this case were measured by means of a Pitot tube inserted in the casing about 3 in. above the top of the shoe. In this plane, practically all of the velocity of the jet from the fan had been converted into pressure head. These pressures were also read by means of the Wahlen gage.

In all cases, the plant was maintained at a predetermined register air temperature for a period of sufficient length to establish thermal equilibrium, and this temperature was held constant while the pressure measurements were being made.

Discussion of Results

The propeller fan delivered 950 cu. ft. of air per minute, and this amount remained practically constant over the whole range of register air temperatures. The observed static pressures with the propeller fan in the 9th installation are shown in Fig. 2. The static pressure corresponding to a register air temperature of 65 deg. fahr. represents the head necessary to overcome the friction in the warm air side of the system including the registers, wall stacks, basement pipes, casings, and shoe between the fan and the casing. It may be noted that this pressure did not exceed 0.01 in. of water, with a cold furnace.

As the register air temperature was increased, the increasing negative, or suction, head created by the furnace combined with the positive pressure head created by the fan and resulted in decreasing values for the observed static pressure. The latter became zero at a register air temperature of 100 deg. fahr., and was negative for all register air temperatures greater than 100 deg. fahr.

Since the observed static pressures at all register air temperatures above 65 deg. fahr. represent the composite effect of the pressure created by the fan and the suction created by the furnace, it is reasonable to assume that the suction head produced by the furnace is represented by the difference between the observed static pressure for the given register air temperature and the observed static pressure at 65 deg. fahr. These differences are shown in the lower curve in Fig. 3. The curve for volume of air circulated per minute under gravity flow alone is also shown in this figure.

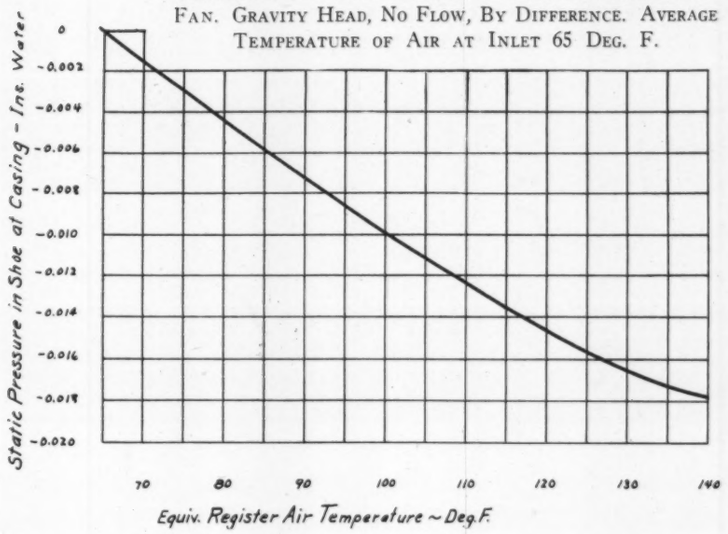
The upper curve in Fig. 3 represents the observed static pressures, or suction heads produced by the furnace under the conditions of gravity flow with the fan not in operation. It may be observed that these suction heads are less than the ones determined by difference, and shown in the lower curve. When the furnace is operating under its own motive head, it must create not only the head necessary to overcome friction but also the velocity head. Hence the observed static pressure will be less than the theoretical head calculated from the difference in weights of the air columns on the hot and the cold sides of the system.

When the fan is operated, it creates the velocity head and probably either all, or part, of the head required to overcome friction. The gravity head obtained by difference, shown in the lower curve, therefore, probably represents the theoretical gravity head, or the gravity head under conditions of no flow. An approximation of the latter may be made by application of the chimney formula:

$$D = 7.64H\left(\frac{1}{T_a} - \frac{1}{T_c}\right)$$

in which D = theoretical draft in inches of water, H = height of chimney in ft., T_a = absolute temperature on cold side of the system in deg. fahr., and T_c = absolute temperature on hot side of the system in deg. fahr. In applying this formula, it was assumed that the height of the second story wall stacks from the grate line to the centers of the registers represented the mean height of the warm air columns, and the average register air tem-

FIG. 5—STATIC PRESSURE IN COLD AIR SHOE. RESEARCH RESIDENCE—7TH INSTALLATION. MULTIBLADE CENTRIFUGAL FAN. GRAVITY HEAD, NO FLOW, BY DIFFERENCE. AVERAGE TEMPERATURE OF AIR AT INLET 65 DEG. F.



perature represented the mean temperature on the hot side. This computation resulted in, $D = -0.0267$ for a register air temperature of 130 deg. fahr. and $D = -0.0151$ for a register air temperature of 100 deg. fahr. The corresponding values read from the lower curve in Fig. 3 were —0.0165 and —0.0100 respectively. This agreement is reasonably close, considering the uncertainty in regard to the actual mean height and actual mean temperature for the system, and tends to confirm the conclusion that the suction heads determined by difference represent the gravity heads for no flow.

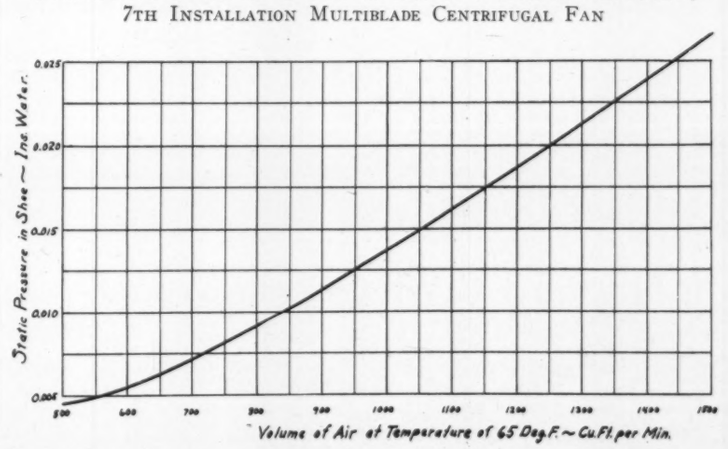
Fig. 4 shows the observed static pressures determined for various register air temperatures and volumes of air circulated with the multiblade centrifugal fan in the 7th installation. These curves also indicate that the observed static pressures decrease as the register air temperatures increase, and in addition that the observed static pressures increase as the volume of air circulated increases. Some inconsistency may be observed in two of the lower points obtained with very low air volumes and high register air temperatures, because under these conditions the furnace *breathed* and air was drawn in through the warm air register in the kitchen.

Fig. 5 shows the theoretical or gravity head under no flow conditions, and exhibits the same characteristics as the lower curve in Fig. 3. The numerical values also agree very closely at given register air temperatures for the two curves.

Fig. 6 shows the static pressures or friction heads for the cold furnace for various volumes of air circulated. The maximum value of 0.025 in. of water was obtained when the volume circulated was practically twice the normal gravity air circulating capacity of the furnace in zero weather. Furthermore, the value of 0.012 in. of water for 950 cu. ft. per min. agrees very closely with that of 0.010 shown for an equivalent register temperature of 65 deg. fahr. in Fig. 2, in which case 950 cu. ft. per min. were circulated by the propeller fan. A somewhat higher pressure is to be expected in the case of the centrifugal fan, since the pressures were measured just outside of the casing and hence included the entry loss for the shoe. The pressures measured in the casing, just above the shoe, with the propeller fan did not include this loss.

The outstanding feature of all of the curves is the fact that the friction loss in a well designed gravity furnace system is small and that the observed heads are very low even with a cold furnace. Furthermore, when the furnace is under heat, these heads become progressively smaller, and assume negative values at the higher register air temperatures.

FIG. 6—STATIC PRESSURE IN COLD AIR SHOE. FAN RUNNING IN COLD FURNACE. TEMPERATURE OF AIR 65 DEG. F. RESEARCH RESIDENCE, 7TH INSTALLATION MULTIBLADE CENTRIFUGAL FAN



PRESIDENT'S PAGE

Will You Do Your Part?

Will you assist Mr. Cecil Farrar, Chairman of the Increase of Membership Committee, by securing at least one new member?

Will you endeavor to come to the Annual Meeting in Philadelphia the last week in January, 1930, when you also will have the privilege of attending the International Heat and Ventilating Exposition?

In this simple way you can do your part to build up *your* industry and make *your* Society of greater influence and usefulness.

Thomas Lewis

Philadelphia Preparing for 36th Annual Meeting, Jan. 27-31, 1930

WHEN the members of the Society meet in their 36th annual gathering at the Benjamin Franklin Hotel, Philadelphia, January 27-31, those who attend will find that their Philadelphia Chapter hosts have prepared an unusual program.

The social activities, particularly for the ladies, are quite elaborate and special committees have been appointed and will work under the direction of M. C. Gillett, who is chairman of the Ladies' Entertainment Committee.

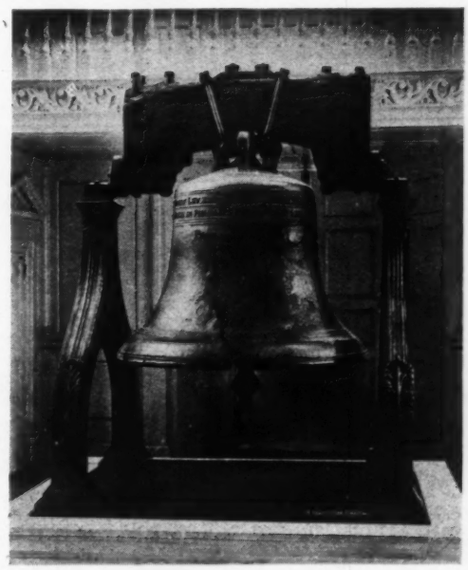
Registration will open on Monday, January 27, at the Benjamin Franklin Hotel and morning sessions will be held in the ballroom.

At the registration desk, the visiting members will be received by M. C. Gillett and F. D. Mensing, assisted by Mrs. M. C. Gillett, Mrs. Thornton Lewis, Mrs. F. D. Mensing, Mrs. R. C. Bolsinger and Mrs. A. J. Nesbitt.

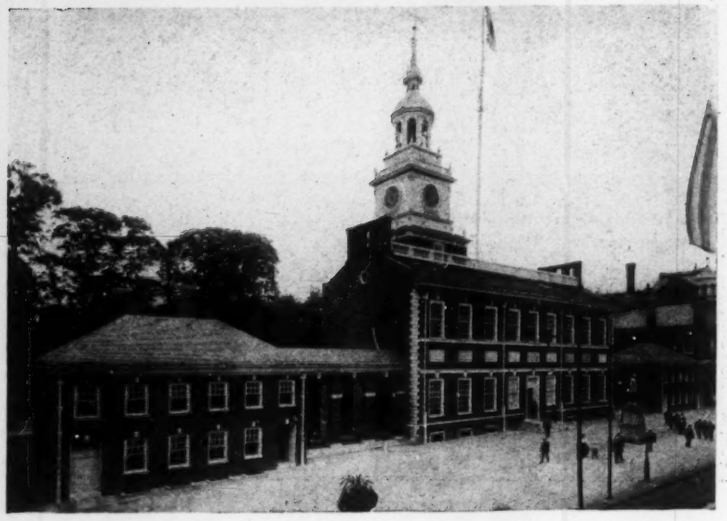
On Monday evening the ladies will be entertained at dinner and the men will have a stag dinner. At eleven o'clock, after the ladies return from the theater, refreshments will be served to both men and women.

A trip to Valley Forge by bus and a view of that historic battle ground will be afforded the ladies, who will also be entertained at luncheon and have a bridge party during the meeting.

The big event will be the annual banquet on Thursday evening, January 30, at the Benjamin Franklin Hotel; this affair is in charge of A. J. Nesbitt. In addition to the customary presentation of the Past President's emblem, several novelties will feature the program, which will be followed by dancing. An additional feature will be the presentation of prizes for the Membership Campaign. The chapter whose percentage of membership increased the greatest between October 15 and January 15, will receive a banner to be held for one year and the individual members who secured



LIBERTY BELL



INDEPENDENCE HALL

the greatest number of members during the same period will be awarded appropriate prizes.

In accordance with the annual custom, the past presidents will be entertained at dinner on Tuesday evening, January 28.

The technical sessions will be opened Tuesday morning in the Benjamin Franklin Hotel by Pres. Thornton Lewis of Philadelphia and each morning members will meet in the ballroom.

The afternoon sessions on Tuesday, Wednesday and Thursday will be held in the Convention Hall of the Commercial Museum in the same building, where the first International Heating and Ventilating Exposition will be in progress.

A technical program of unusual interest has been prepared under the direction of H. H. Angus, A. J. Nesbitt and Prof. F. B. Rowley and some of the subjects to be discussed follow:

Preventing Condensation on Interior Building Surfaces, by Paul D. Close.

Pressure Difference Across Windows in Relation to Wind Velocity, by J. E. Emswiler and W. C. Randall.

Some Studies of Airation of Garages, by W. C. Randall and L. W. Leonhard.

Electric Power Generation by Process Steam, by L. A. Harding.

Air Infiltration Through Various Types of Brick Wall Construction, by G. L. Larson, D. W. Nelson and C. Braatz.

Air Conditioning of the Halls of Congress, by L. L. Lewis and A. E. Stacey.

Panel Warming, by L. J. Fowler.

Measurement of the Flow of Air Through Registers and Grilles, by Prof. Davies.

Surface Transmission Coefficients, by Rowley, Algren, and Blackshaw.

Wind Velocity Gradients Near a Wall, by F. C. Houghten.

Rating of Heating Boilers by Their Physical Characteristics, by C. E. Bronson.

A Method of Testing Unit Heaters Suitable for Field Tests, by L. S. O'Bannon.

While this presents some changes in the tentative program originally announced, there is no doubt that the subjects covered will be of great interest to members who attend.

Various committee reports and several codes will be discussed during the technical sessions and topics have been so arranged that ample time will be given for discussions on the floor.

The manufacturers of heating and ventilating equipment of Philadelphia have combined to extend an invitation for an inspection trip of their plants on Monday, January 27, and it is anticipated that a large number will want to see the process of manufacture of heating and ventilating equipment in the plants of their fellow-members. Complete information will be available at the registration desk in the Benjamin Franklin Hotel.

In addition to this, during the four days' meeting, time has been allotted for a visit to the Heating and Ventilating Exposition, as well as the many places of historic interest which are to be found in Philadelphia.

Many New Members Join A. S. H. V. E.

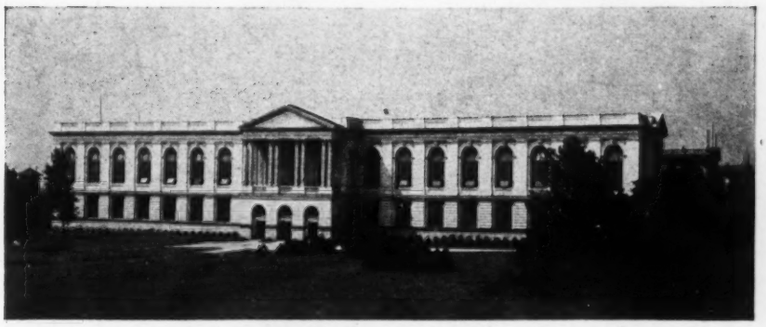
The first letter addressed by C. W. Farrar, chairman of the Committee on Increase of Membership, to all Society members announcing the campaign for new members during the three months, October 15 to January 15, has resulted in the receipt of 50 new applications during the first month. The leaders at present are western members from Detroit and Kansas City.

A second letter from Mr. Farrar to all Society members was mailed November 15 and in it he pointed out places where eligible candidates might be found.

According to the present rules each member of the Society is requested to send in the application of one or more new members by January 15, 1930, and for their effort a suitable reward has been offered.

The regulations of the campaign are as follows:

1. The Society member whose name appears as first proposer on the greatest number of membership applications between October 15, 1929, and January 15, 1930, will receive a gold watch with Society emblem; for the second greatest number a copy of Vol. 2, Heating and Ventilation (revised) by Harding and Willard; for the third greatest number a pair of cuff links with Society emblem; for the fourth greatest number a watch fob with Society emblem and for the fifth greatest number a solid gold Society pin.
2. For the Chapter whose percentage of membership is increased by the greatest amount between October 15 and January 15 a banner will be awarded and will remain in possession of the chapter for one year.
3. Officers of the Society and members of the Council are not eligible for the prizes listed.
4. Awards are to be made at the banquet of the annual meeting in Philadelphia.
5. All applications must be properly filled in as required by the Society's Constitution and By-Laws and initiation fee check must be attached.



COMMERCIAL MUSEUM OF PHILADELPHIA

Visit First Heating and Ventilating Exposition

WHEN the heating and ventilating profession visits Philadelphia in January to see the first International Exposition of Heating and Ventilating Equipment at the Commercial Museum, it will find this great building crowded with the products produced for the comfort and health of mankind.

In addition to the most modern equipment available for homes, public buildings, and industrial plants, special effort has been made to arrange a group of educational and historical exhibits which will show the progress of the industry.

In addition to the other co-operating associations, the society will maintain an information and reception booth near the entrance of the Exhibit Hall and the Research Laboratory and its ten co-operating universities will plan to tell the story of research problems now being investigated in their laboratories. The society's laboratory in Pittsburgh, located at the U. S. Bureau of Mines, will demonstrate the wind effect on heat transmission and show the effect of heat and moisture loss on human comfort.

A model of the apparatus used to determine air flow through grilles is being prepared by Armour Institute of Technology. The University of Kentucky promises a set-up for testing unit heaters and Harvard University School of Public Health will demonstrate the ionization of air. In addition to these expected exhibits, the following universities co-operating with the Society's Research Laboratory have the presentation of appropriate exhibits under consideration. Carnegie Institute of Technology, Yale University, University of Wisconsin, University of Minnesota, Texas Agricultural and Mechanical College, Purdue University, and Washington University.

The management of the Exhibition has invited the Society members to visit the Commercial Museum and their registration badges will admit them to the show.

A special bus and taxi service has been arranged for between the Benjamin Franklin Hotel and the Commercial Museum.

Among the exhibitors who have reserved space up to November 15 are the following:

Aerofin Corp.
Aerologist, The.
Aerovent Ventilating Co.
Air Control Corp. of New York.
Airmaster Corp.
Air Reduction Sales Co.
Alexander Bros., Inc.
Allen Air Turbine Ventilator Co.
American District Steam Co.
American Gas Association.
American Gas Products Corp.
American Metal Products Co.
American Oil Burner Assoc., Inc.
American Oil Burners Corp.
American Radiator Corp.
American Warming & Ventilating Co.
Ames Pump Co.
Anthracite Coal Service.
Armstrong Machine Works.
Automatic Burner Corp.
Barnes & Jones.
Beckwith Co.
Bishop & Babcock Sales Co.
B-Line Boiler Co.
Bristol Co., The.
Brown Instrument Co.
Bryan Steam Corp.
Bryant Heater & Mfg. Co.
Builders Iron Foundry.
Burnham Boiler Corp.
Carrier Engineering Corp.
Century Engineering Corp.
Celotex Co.
Champion Sales Co.
Cochrane Co.
Columbia Burner Co.
Combustion Fuel Oil Burner Co.
Combustion Specialties Corp.
Cooling & Air Conditioning Corp.
Cook Electric Co.
Copper Radiator Sales Corp.
Coppus Engineering Corp.
Crane Co.
Chicago Pump Co.
Cox, Abram Co.
Crystal Oil Burner Corp.
Culbert-Whitby Co.
Direct Control Valve Co.
Domestic Engineering.
Domestic Stoker Co.
Draft-A-Justor Corp.
Dunham Co., C. A.
Durston Gear Corp.
Eagan & Co., Walter H.
Economy Oil Burner Co.
Economy Pumping Machinery Co.
Elliott & Co., Edwin.
EverHot Heater Co.
Flagg & Co., Stanley G.
Frank Heater & Eng. Co., O. E.
Foxboro Co.
Fuel Oil & Temperature Journal.
Fulton Sylphon Co.
General Electric Co.
General Gas Light Co.
Grinnell Co., Inc.
Haines & Co., Wm. S.
Hardinge Bros.
Hart & Crouse Co.
Hart & Hutchinson Co.
Hartzell Propeller Co.
Heating Journals, Inc.
Heating, Piping and Air Conditioning.
Heating and Ventilating.
Heggie-Simplex Boiler Co.
Heilman Boiler Works.
Heintz Mfg. Co.
Hill Company, E. Vernon.
Hoffman Specialty Co., Inc.
Hirschman Co., W. F.
Humphrey Radiant Fire Mantel, The.
Illinois Engineering Co.
International Boiler Mfg. Co.
Iona Ventilator Co., Inc.
International Burners Corp.
Janette Mfg. Co.
Johnson Company, S. T.
Johnson Service Co.
Kelly Brass. Works.
Kelsey Heating Co.
Kewanee Boiler Corp.
Kieley & Mueller, Inc.
Korfund Co., Inc.
Langenberg Mfg. Co.
Lehigh Fan & Blower Co.
Leslie Co.
Linde Air Products Co.
Liquidometer Corp.
Marr Oil Heat Machine Corp.
Marsh & Co., James P.
Massachusetts Blower Co.
McDonnell & Miller.
McIllvaine Burner Corp.
McQuay Radiator Corp.
Mears-Kane-Ofeldt, Inc.
Mercoid Corp.
Midwest Mfg. Co., Inc.
Milwaukee Air Pump Co.
Minneapolis-Honeywell Reg. Co.
Mineral Felt Insulating Co.
Modine Mfg. Co.
Molby Boiler Co.
Moterstoker Corp.
Monarch Metal Weatherstrip Co.
Motor Wheel Corp.
McCord Radiator & Mfg. Co.
Multicell Radiator Co.
Meyer Furnace Co.
May Oil Burner Corp.
Mueller Furnace Co., L. J.
Nash Engineering Co.
National Regulator Co.
Nesbit, Inc., John J.
Newport Boiler Co.

National Radiator Co.
National Warm Air Heating Ass'n.
O. E. Specialty Mfg. Co.
Orr & Semtower, Inc.
Parks-Cramer Co.
Penn Electric Swtich Co.
Pennsylvania Furnace & Iron Co.
Pierce, Butler & Pierce Mfg. Corp.
Piqua Electric Mfg. Co.
Pittsburgh Water Heater Co.
Power Efficiency Corp.
Rawlplug Co., Inc.
Raymond Co., F. I.
Richmond Radiator Co.
Robertson Co., H. H.
Rome Brass Radiator Corp.
Rome-Turney Radiator Corp., The.
Roper Corp., George D.
Ric-Wil Co.
Richardson & Boynton Co.
Sarco Company, The.
Schade Valve Mfg. Co.
Sheffler-Gross Co., Inc.
Skinner Bros. Mfg. Co., Inc.
Silent Automatic Corp.
Skidmore Corp.
Smith Twin Tubular Boiler Co.
Spencer Heater Co.
Sprayo-Flake Co.
Star Expansion Bolt Co.
Stat-Amatic Inst. & Appli. Co., The.
Stickle Steam Specialties Co.
Strandwitz & Scott, Inc.
Sweet & Doyle Foundry & Mach. Co.
Sterling Engineering Co.
Sheer Company, H. M.
Schutte & Koerting Co.
Staynew Filter Corp.
Taco Heaters, Inc.
Tallmadge & Co., Inc., Webster.
Teesdale Mfg. Co.
Texo Sales Co., Inc.
Thatcher Co.
Time-O-Stat Controls Co.
Trerice Co., H. O.
Thermal Units Company.
Thrush, & Co., H. A.
Union Carbide Co.
United States Gypsum Co.
United States Radiator Co.
U. S. Bureau of Standards.
Vinco Co., Inc.
Warren Webster & Co.
Weil Pump Co.
Westinghouse Elec. & Mfg. Co.
Wickes Boiler Co.
Wilcolator Co.
Wilson Bros.
Winchester Repeating Arms Co.
Winslow Boiler & Engrg. Co.
Wood Conversion Co.
Wright Austin Co.
York Heating & Ventilating Co.
Young Radiator Co.
Young Pump Co.
Yale & Towne Mfg. Co.

Death of Ellsworth H. Fritz

Word has reached us of the death of Ellsworth H. Fritz of Philadelphia, Pa., an Associate Member of the Society.

Mr. Fritz, who joined the Society in December, 1928, was deeply interested in the development and welfare of the organization, and gave his aid wherever possible to its furtherance.

His business experience included connections with the Spencer Heater Co., and Taco Heater, Inc., as a designer and sales engineer.

Mr. Fritz's passing is a matter of great regret to those who knew him and valued his association and friendship.

Death of Irving London

It is with deep regret that we learn of the death of one of the younger members of the Society, Irving London of Brooklyn, N. Y., who passed away on July 11, 1929.

Mr. London was elected to Junior Membership in the Society in 1924.

He was a graduate of Cooper Union School, New York, and completed an extension course in Mechanical Engineering at Columbia University.

Mr. London's first heating experience was with Roase and L. A. Goldstone, architects, New York. Later he was employed by the Raisler Heating Company of New York, as Chief Draftsman and Estimator, and laid out the heating systems of many large buildings.

His interest in the Society was maintained from the time he became a member, and he will be greatly missed by his many friends.

Local Chapter Reports

Illinois Chapter

October 14, 1929: The regular annual meeting of the Illinois Chapter of the Society was held at the Sherman Hotel, Chicago, on Monday, October 14, 1929, at which 73 members and guests were present, an attendance believed to be the largest at any annual meeting of the Chapter.

Aside from the privilege of having as guests the president of the Society, Thornton Lewis, and secretary, A. V. Hutchinson, the important business of the evening was the election of officers.

The following officers were elected to serve the Chapter for the ensuing year:

President, H. G. Thomas.
Vice-President, T. H. Monaghan.
Secretary, C. W. DeLand.
Treasurer, C. W. Johnson.
Board of Governors, E. P. Heckel, M. S. Good and J. H. O'Brien.

The newly elected officers were then introduced by President Thomas, who also introduced L. J. Pitcher, winner of the Society Research Golf Trophy for the second time.

President Lewis addressed the members and guests, speaking on the future of the Society and explaining the value of the research work done at the Laboratory at Pittsburgh. He also mentioned the cooperative work with the *Heating and Piping Contractors National Association,* the Government and the various Universities.

President Lewis also spoke of the appreciation the engineers in Europe and Great Britain have for the work over here, and stated that the French are translating THE GUIDE and using it in the University of Paris.

President Lewis then announced the Annual Meeting of the Society at Philadelphia, the week of January 27, at the Benjamin Franklin Hotel, which will be held at the same time that the International Heating and Ventilating Exposition will take place. He also mentioned that the Council is considering making the next Summer Meeting a joint one with the *American Society of Refrigerating Engineers.*

C. W. Farrar, who is in charge of the increase in membership work for the Society, was then introduced, giving the members an idea of the new member contest.

On motion of Mr. Heckel the minutes of the April 8 meeting were dispensed with, which was followed by adjournment.

Massachusetts Chapter

October 8, 1929. The first meeting of the season was held at the Engineers' Club, Boston, on October 8, 1929, with 40 members and guests present.

Immediately after the dinner the new Chapter president, T. F. McCoy, made a short address of welcome.

At the business session the question of changing the meeting time from the evening to noon caused much discussion, which was finally left to the decision of the Board of Governors.

The speakers of the evening were Thornton Lewis, president of the AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS, and C. W. Farrar, chairman of the Membership Committee of the Society. A. V. Hutchinson, secretary of the Society was also one of the welcome guests of the evening.

Mr. Lewis gave a very interesting talk on the future of the AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS, while Mr. Farrar spoke on the necessity for and ways and means of increasing the membership of the Society.

The speakers were enthusiastically received and as Secretary Webb stated, the Chapter was very fortunate in being able to start the series of meetings with such distinguished guests.

Michigan Chapter

October 14, 1929. The 1929-1930 season of the Michigan Chapter of the AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS opened on October 14, with a meeting at the Cadillac Athletic Club, with an attendance of 85 members and guests.

The members and guests were officially welcomed by President W. G. Boales, who complimented them for their loyalty in turning out in such a large number for the opening meeting.

After the reading of the minutes by the Secretary and the announcement by the various chairmen of committees, President Boales introduced Ralph Collamore as master of ceremonies to present the past presidents of the Michigan Chapter to the audience.

Mr. Collamore paid a very fine tribute to the late John R. Allen, who was one of the past-presidents, touching upon the splendid work which Mr. Allen had done not only in the interest of the Society but in the interest of the entire profession.

F. R. Still, New York, was unable to attend the meeting, but a letter from him was read by Mr. Collamore.

The other past-presidents introduced by Mr. Collamore were, J. R. McColl, E. E. McNair, W. B. Johnston, E. M. Harrigan, J. B. Dill, F. W. Johnson, R. S. M. Wilde, J. F. McIntire and W. A. Rowe, and each in turn responded with a short talk. W. F. Verner, W. T. Harms and N. B. Calvert were unable to attend this meeting.

Mr. Collamore closed by proposing a toast to the memory of Professor Allen, as a silent tribute to him.

The speaker of the evening, L. A. Harding, first vice-president of the Society, was then introduced by President Boales. Mr. Harding chose for his subject Power from Process Steam, which he delivered in a most entertaining manner, using slides to illustrate. Mr. Harding brought out as his principal theme the fact that to increase efficiency of the average steam plant, it could be done by increasing the steam pressure, by adding superheat or by reducing the back pressure, and his lecture was devoted to amplifying this premise.

At the conclusion of Mr. Harding's address a discussion ensued, which was followed by adjournment.

New York Chapter

October 21, 1929. The first meeting of the New York Chapter of the 1929-30 season was held at the Building Trades Club and was well attended.

The speakers of the evening were W. E. Taylor and M. E. Durkee of the *Heating and Piping Contractors' National Association*, New York, who spoke on the subject of Certified Heating, What It Is and How It Operates.

Mr. Durkee stated that certified heating is a measuring stick for the correct heating installation for any specific building. Certified heating installations, he stated, are regulated by a code of standards which governs the calculation and distribution of radiation, the size and arrangement of piping, and the selection of boiler and chimney to be provided. While certified heating applies only to the class of work where it is not customary to engage the services of an engineer, Mr. Durkee stated that it is expected that the experiences with certified heating will bring a greater appreciation for the value and economy of a correctly designed and installed heating system.

It was stated that certified heating provides an ideal medium through which all branches of the heating industry may cooperate to elevate the standards of the business. It brings to the manufacturer a means of obtaining correct installation of his apparatus, whereas the architect is relieved of the responsibility of providing satisfactory results for his client, while the builder obtains a trade mark of quality which brings him the benefits of the advertising of certified heating, greater ease in financing, and less responsibility in selling or leasing.

Western New York Chapter

November 11, 1929. The November meeting of the Western New York Chapter of the AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS was held in the Rathskeller of the Markeen Hotel, Buffalo, N. Y., on the night of November 11. About 30 members and guests were present at the dinner, and about 6 more came in later for the meeting.

C. W. Farrar, Chairman of the National Committee to Increase Membership, gave an inspiring talk and appeal for a greater membership. Mr. Farrar described the prizes to be won for the Chapter and individuals bringing in the most new members. L. A. Harding amplified Mr. Farrar's remarks with some well chosen ideas on how to increase the local and national membership.

Fletcher Burke, chairman of the Chapter Membership Committee, also urged that greater efforts be put forth to bring new members into the organization.

Mr. Donnelly of Syracuse was principal speaker of the evening, and his subject, The New Era in Anthracite, was handled in a most interesting way. He brought out the fact that the *Association of Anthracite Producers* was exerting its energy in finding out the varied uses to which anthracite coal is put, and to find new uses for it. It is a problem of education, and the greatest problem is the house user. Mr. Donnelly brought out that the A. S. H. & V. E. might well interest themselves in the many complexities attendant to the use of coal.

A general discussion followed in which most of the members took part.

A nominating committee of Past Presidents was appointed to submit a list of nominations for next year's officers.

October 15th, 1929. The October meeting of the Western New York Chapter was held at the Hotel Markeen, Buffalo, N. Y., on October 15th.

The record for good attendance was maintained, about 55 members and guests being at hand for the excellent dinner, and about six more arriving later for the meeting.

Roswell Farnham was appointed as a committee of one to foster interest in attendance at the Annual Meeting to be held in Philadelphia in January.

The speaker of the evening was L. A. Harding, whose talk on Power from Process Steam was most interesting and held the undivided attention of the members until the end.

A general discussion followed, in which Messrs. Burke, Harding, Schnelling, Hirschman and Porzell took part. The past presidents of the Society, five of whom were present, were called upon for a few words.

An Armistice Day meeting was planned for November 11th, at the Rathskeller of the Markeen.

CANDIDATES FOR MEMBERSHIP

The Constitution of the Society, as now amended, requires the following mode of procedure in voting on applicants for membership in the Society. All applications for membership are to be sent to the Secretary and the name of applicants and their references shall be printed in the next issue of the Journal of the Society or sent to the members in other approved manner as ordered by the Council. When replies are received from references, the Candidate's application shall be submitted to and acted upon by the Membership Committee as soon as possible.

When the Membership Committee has acted favorably upon a Candidate's application and assigned his grade, the Council shall vote upon the election of the proposed Candidate for membership by letter ballot. During the past month 47 applications for membership have been received and the names of these men and their sponsors are published in the following list.

Members are requested to scrutinize the list with care. The Membership Committee, and in turn the Council, urge the members to assume their share of the responsibility of receiving these candidates into membership by advising the Secretary promptly of any whose eligibility for membership is in any way questioned. All correspondence in regard to such matters is strictly confidential, and is solely for the good of the Society, which it is the duty of every member to promote.

Unless objection is made by some member by January 1, 1930, these candidates will be balloted upon by the Council. Those elected to membership will be notified by the Secretary, immediately after election.

CANDIDATES	REFERENCES	
	Proposers	*Seconders*
Anderson, William M., Jr., Engr., 600 Schuylkill Ave., Philadelphia, Pa.	Wilbur F. Smith A. C. Edgar	C. V. Haynes Raymond E. Jones
Beavers, George Robert, Engrg. Dept., The Canadian Blower & Forge Co., Ltd., Woodside Park, Kitchener, Ont., Canada.	C. A. Booth H. H. Angus	M. Barry Watson
Bennett, Edwin Alfred, American Blower Corp., New York, N. Y.	O. O. Oaks F. R. Still	Herbert E. Barth Wallace M. Hyman
Corlett, Lawrence Donald, Smith, Hinchman & Grylls, Detroit, Mich.	G. H. Giguere L. L. Smith	Wm. A. Blessed H. C. Kappler
Cotter, Leonard F., Estimator and Construction Foreman, J. J. Cotter Co., Springfield, Mass.	W. T. Jones T. F. McCoy	John S. Webb Alfred Kellogg
Dawson, Thomas L., Thos. L. Dawson Co., Kansas City, Mo.	Ray B. Mason C. A. Burton	Walter E. Gillham Carl Clegg
Duncan, William A., Service Engr., Dominion Oxygen Co., Ltd., Toronto, Ont., Canada.	Jas. S. Paterson E. Addy	W. G. Sheppard Grant E. Cole
Durkee, Merritt E., Htg. and Piping Contractors, New York City Association, New York, N. Y.	Wm. J. Olvany F. E. W. Beebe	Henry B. Gombers E. J. Richie
Erickson, Harry H., Haynes Selling Co., Philadelphia, Pa.	A. E. Kriebel Merrill F. Blankin	Alan A. Miller Jos. H. Hucker
Everetts, John, Jr., Cooling & Air Conditioning Corp., New York, N. Y.	R. E. Keyes W. L. Fleisher	
Flanagan, Edward T., Branch Sales Mgr., C. A. Dunham Co., Ltd., Toronto, Ont., Canada.	A. J. Dickey A. S. Leitch	M. Barry Watson H. H. Angus
Glanz, Edward, Glanz & Killian Co., Detroit Mich.	G. H. Giguere H. M. Stephen	H. C. Kappler W. A. Blessed
Groom, Harold L., Ch. Engr., Erection and Service Depts., Carrier Engrg. Corp., London, England.	Thornton Lewis J. I. Lyle	S. L. Groom W. H. Carrier
Haas, Emil, Jr., Natkin Engrg. Co., Kansas City, Mo.	Sidney Pine Carl Clegg	Henry J. Nottberg Ray B. Mason
Hard, Alva L., Freyn Bros., Detroit, Mich.	G. H. Giguere H. M. Stephen	W. G. Boales E. E. Dubry
Harrigan, Edward R., Harrigan & Reid Co., Detroit, Mich.	G. H. Giguere W. J. Whelan	H. C. Kappler W. A. Blessed
Harrigan, Howard H., Consolidated Ashcroft Hancock Co., Detroit, Mich.	G. H. Giguere Herman C. Kappler	Wm. A. Blessed E. H. Clark
Harrington, Elliott, Ind. Engrg. Dept., General Electric Co., Schenectady, N. Y.	H. H. Vernon, (*Non-member*) H. A. Winne (*Non-member*)	R. S. Sage (*Non-member*) H. W. Rogers (*Non-member*)
Hicks, William W., W. W. Hicks & Co., Winnipeg, Manitoba, Canada.	R. G. Olson C. T. Morse	J. F. G. Miller
Johnson, Leslie Otto, H. Y. Keeler, Mech. Engr., Huntington, W. Va.	Q. D. Schwab C. A. Thinn	R. E. Atkinson E. A. Taylor
Knab, Edward A., Pres., Edward A. Knab, Heating Contrs., Milwaukee, Wis. (Advancement)	F. Dannies V. Berghoefer	E. A. Jones J. Jung
Lovegren, H. M., B. Hoffman Mfg. Co., Milwaukee, Wis. (Advancement)	F. H. Gaylord S. H. Berringer	N. P. Fenner F. G. Weimer
McPherson, William A., Chief, Htg. and Vtg. Div., Schoolhouse Dept., City of Boston, Mass.	Jas. A. Myrick Conway Kiewitz	Wm. N. McKenna H. B. Wiegner
Miller, Donald S., York Heating & Ventilating Corp., Philadelphia, Pa.	H. B. Hedges Thornton Lewis	Clarence E. Scott C. D. Graham
Moor, Rhea Franklin, General Heating Specialty Co., Kansas City, Mo.	Carl A. Weiss Carl Clegg	Walter E. Gillham E. K. Campbell
Nemenye, Louis, Htg. and Vtg. Engr., A. H. Karl, Inc., Mt. Vernon, N. Y.	O. O. Oaks M. Wm. Ehrlich	C. W. Obert J. E. Titzell
Nessi, Andri, Nessi Freres & Cie, Paris, France.	A. Beaurrienne R. Modiano	

PARKER, DUDLEY FULLER, Eastern Mgr., National Regulator Co., New York, N. Y.	F. C. Purcell F. E. W. Beebe	F. G. McCann O. Vogelbach
PITCHER, LESTER JAMES, Illinois Engrg. Co., Chicago, Ill. (Advancement)	W. T. Walters J. C. Matchett	F. H. Gaylord W. A. Mertz
RICHARDS, EDWARD, Partner, B. C. Moss Co., Kansas City, Mo.	Henry J. Nottberg John H. Kitchen	Carl Clegg Walter E. Gillham
RICHARDSON, HENRY THOMAS, Vice-Pres., Richardson & Boynton Co., New York, N. Y.	C. W. Farrar A. C. Willard	E. B. Langenberg A. W. Williams
ROARKE, HUGH B., Dist. Mgr., Detroit Stoker Co., Buffalo, N. Y.	Wm. G. Fraser Chas. Evans	L. A. Harding H. F. Hutzel
RYAN, CAMPBELL, Staff Mgr., Johns-Manville Corp., New York, N. Y.	P. D. Close J. H. Bracken	
SNYDER, ALLEN K., Carrier Engrg. Corp., Newark, N. J.	W. G. Hillen J. I. Lyle	H. Worsham M. S. Smith
SONNEBORN, ROBERT H., Youngstown Sheet & Tube Co., Detroit, Mich.	G. H. Giguere Wm. J. Whelan	Wm. G. Boales E. E. Dubry
THOMMEN, ADOLPH A., Supt., Bloomer Heating & Ventilating Co., Chicago, Ill.	John Howatt Edward J. Finan	James J. Finan James P. Fleming
THOMMEN, ARTHUR R., Shop Foreman, Bloomer Heating & Ventilating Co., Chicago, Ill.	James J. Finan Edward J. Finan	John Howatt James P. Fleming
TIERNEY, LAWRENCE J. J., Owner, Tierney, Wilson Co., Boston, Mass.	Thos. F. McCoy W. T. Jones	Alfred Kellogg F. D. B. Ingalls
TRAUGOTT, MORTIMER, Dist. Sales Mgr., Bryant Heater & Mfg. Co., Cleveland, Ohio.	R. E. Jones W. E. Stark	F. W. Wandless T. W. Cooper
TRULSON, ARTHUR F., Smith, Hinchman & Grylls, Detroit, Mich.	G. H. Giguere Wm. A. Blessed	E. E. Dubry H. M. Stephen
TURLAND, CHARLES H., Asst. Mgr. and Vice-Pres., Acme Fan & Blower Co., Ltd., Winnipeg, Manitoba, Canada.	James Mackie Chas. D. Kirk	B. G. Jones
VOGT, JOSEPH B., Smith, Hinchman & Grylls, Detroit, Mich.	G. H. Giguere L. L. Smith	H. M. Stephen E. E. Dubry
WALLACE, R. ROBERT, B. F. Sturtevant Co., Chicago, Ill.	W. P. McFarland E. W. Rietz	R. J. Coughlin H. J. Clark
WARD, WILLIAM T., Heating Contr. and Prop., 18 Castlefield Ave., Toronto, Ont., Canada.	W. R. Blackhall H. J. Church	R. J. Millar R. W. McHenry
WELLS, ERIC E., Civil Engr., Sarco Co., Inc., New York, N. Y.	W. R. Blackhall J. O'Neill	R. J. Millar A. S. Leitch
WILSON, ARTHUR C., Partner, Wilson Bros., Collingdale, Pa.	A. E. Kriebel F. W. Wandless	A. H. MacDade F. T. Phillips
WINQUIST, WALTER J., Clark, MacMullen & Riley, New York, N. Y.	J. H. Walsh A. A. Adler	W. G. Kreitner W. R. Zuhlke
WINQUIST, WILLIAM M., Sales Engr., Silent Automatic Sales Corp., New York, N. Y.	J. H. Walsh A. A. Adler	W. G. Kreitner W. R. Zuhlke

Candidates Elected December, 1929

In the past issues of the Journal of the Society there were posted among the list of Candidates for Membership, 15 candidates for election in the different grades of Membership, whose names have been balloted upon by the Council. We are now instructed by the Council to post herewith, as required by Art. II, Sec. VIII, of the By-Laws, the following list of candidates elected:

MEMBERS

BARRY, CURTIS P., Narowetz Heating & Ventilating Co., 1711 Maypole Ave., Chicago, Ill.

BELT, NEWTON O., Asst. Chief Engr., Armstrong Cork Co., Lancaster, Pa.

MILLARD, JULIUS W., Dist. Mgr., York Heating & Ventilating Corp., 1541 Sansom St., Philadelphia, Pa.

SMITH, ELMER GILLAM, Asst. Prof. of Physics, Texas A. & M. College, College Station, Tex.

ASSOCIATES

GILLIAM, OLIVER F., Sales Engr., York Heating & Ventilating Corp., 205 W. Wacker St., Chicago, Ill.

MATHER, HARRY H., Philadelphia Electric Co., 1000 Chestnut St., Philadelphia, Pa.

MUSSON, JOSEPH R., Charge of Sales, Radiator Div., Heintz Mfg. Co., Front and Olney Ave., Philadelphia, Pa.

PAYSON, CHARLES H., Owen, Saylor & Payson, 505 Interstate Bldg., Kansas City, Mo.

PHILLIPS, WILLIAM J., 520 West First St., Royal Oak, Mich.

SIMPSON, RICHARD B., Asst. Mgr., Building Dept., The Celotex Co., 919 N. Michigan Ave., Chicago, Ill.

JUNIORS

CARRIER, EARL GARDNER, Carrier Engrg. Corp., 850 Frelinghuysen Ave., Newark, N. J.

CRESSY, RALPH E., Sales Engr., Hoffman Specialty Co., 1346 Broadway, Detroit, Mich.

MARTINEZ, JUAN JOSE, Asst. Supt., Mech. Dept., The Mexican Light & Power Co., Mexico City, Mexico.

ROBERTS, EDWARD F., JR., Engrg. Draftsman, Haynes Selling Co., Inc., 2013 Sansom St., Philadelphia, Pa.

WRIGHT, M. BIRNEY, Instructor, Case School of Applied Science, Cleveland, Ohio.

Heating·Piping and Air Conditioning

EDITORIALS

Piping's Place

Piping is a word that brings up a picture of distributing steam, water, air, oil, gas, refrigerants and various liquids and chemicals to the countless uses for heat, power and process work in building and plant. It is a word that brings up a picture of pipe, valves, fittings, pumps, traps, coverings, tools and all such products that go to make up industrial and heating piping systems. It is a word that brings up a picture of the consulting engineer who lays out such systems, of the contractor who installs them and of the engineer in industrial plants who is in charge of their maintenance and extension. It is a word to conjure with.

In terms of volume—and thinking of pipe in feet, miles or tonnage—piping is a tremendous part of this commercial and industrial world. In terms of engineering—and thinking of piping design, piping erection and piping maintenance—piping is a serious and important study. It should hold no runner-up position to power, machinery and other interests. It is a service, an industry of its own.

To emphasize its importance we quote A. W. Moulder:

"Industrial piping is doubtless the most important transportation system of industry. Instead of conveying goods, machinery and a variety of products, it conveys steam or liquid for power, heat or some other necessary adjunct to production. American business should think of piping in terms of transportation, and transportation is a matter of getting anything somewhere at the least possible cost.

"Cost in transportation is emphatically not initial expense, but the cost of maintenance, the cost of hauling, switching and unloading cars and a variety of other items. In commodity transportation, freight and express rates are constant reminders of what cost actually is. In industrial transportation, as represented by a piping system, the freight or express rates are paid in the boiler house or pumping station. The man who ships heat or energy from a boiler to a machine through a pipe line pays the freight at every fitting, joint and bend. He pays for maintenance, depreciation and obsolescence."

The code for pressure piping, now in some of its divisions before the industry for critical review, is another current reminder of piping's place in the sun. Power piping, gas and air piping, hydraulic piping, oil piping and refrigeration piping are all receiving the study of leaders in piping engineering in order that a national code may be effected to insure the proper design, proper materials, proper installation and proper care of "industry's transportation system."

Separate and distinct from the processes which it unites—namely, the generation and the utilization of heat and power—piping holds its own place, the basis of practically every mechanical service in building or plant.

Air Conditioning—Well on Its Way

Air conditioning in its present accepted meaning had its inception some twenty-five years ago. Since then it has gone into plants in more than two hundred different industries and freed producers from dependence upon climatic conditions. Since then it has gone into theaters, department stores, office buildings, clubs, hospitals, schools and homes and freed human beings from discomfort and sickness caused by nature's climatic vagaries.

Speaking for itself in dollars saved and comfort created, it has found growing acceptance each year by industry and by the public. It has taught us all to be discontented with excess or lack of heat and humidity. It has taught us all that we do not have to put up with it. And that is a feeling that is going to multiply the uses of air conditioning in the years to come.

Along with this "air conditioning consciousness" of the public—in fact, ahead of it—have gone the engineering research and experience which have made it possible to supply the condition which has created this acceptance. And as air conditioning continues to grow it continues to attract more engineers who are to take present knowledge and develop it further.

It is a sound situation throughout—a needed service that has proved its worth and the brains and facilities to assure rapid development.

Pooling Scientific Knowledge

We are today entering upon a great period of pooling scientific knowledge.

The Department of Commerce lists in its miscellaneous bulletin No. 9, dated December 6, 1927, and supplement thereto, January 4, 1929, 586 testing and research laboratories in the United States. Of this number 401 are commercial testing laboratories and 185 are college research laboratories.

Exactly 100 different kinds of tests are listed as being undertaken by these 586 laboratories. This would indicate that on an average there are 5.86 laboratories devoted to some phase of each subject.

Of these 100 subjects, 87 have more or less close contact with the fields of piping, heating and air conditioning.

Many industries are still singularly backward in taking advantage of research that is available, or in conducting research on their own account. In the meantime the heating, piping and air conditioning engineer and contractor should consider himself in a happy and strategic position. As one man expressed it, so far as research and pooling of scientific information in heating, piping and air conditioning is concerned, "We are in a perfectly satisfactory, unsatisfied but not dissatisfied condition."

Technical Tourneys

We have no record of when the first convention was held; without a doubt, however, the jousts and tourneys of medieval times were the forerunners of the modern convention with its technical sessions, discussions and exposition.

When knighthood was in flower, the leaders from all the land gathered together annually to get the latest dope on the proper method of handling a lance; in other words, they wished to keep posted on their business. There are some who liken those medieval meetings to athletic contests, but we must remember that, in an age when fighting claimed the greater part of a man's time, skill with the instruments of warfare became essential to "business" success.

Who can say how much a King Arthur or a Sir Launcelot learned from these yearly gatherings? No doubt many a fire-breathing dragon would be roaming the earth today had not an ambitious knight picked up a few valuable tips at his convention on the latest methods of slaying such creatures. The knight could not afford to remain ignorant of the improvements in equipment; were he to do so, some competitor was liable to return from Canterbury with a suit of mail, or a lance, or a method of utilizing these tools that would soon defeat the efforts of our knight who remained at home.

Just so with the knight of engineering; through the medium of the annual engineering conventions, he himself keeps up-to-date. He cannot afford to miss these meetings where technical information is exchanged.

Few of the knights who jousted were unknown; their habit of keeping posted on new developments gave them the knowledge to carve prominent niches for themselves in knighthood's hall of fame.

The Building Situation

There has been a general feeling in the construction field, as a result of the bear stock market, that building operations will now attract much of the money which for the last year has found seemingly greater returns in the market. It is a feeling the truth of which will mean a great deal to the engineering and contracting field, and a feeling based on a logical interpretation of economic laws. Building leaders recognize, at the same time, that such laws do not operate to change a condition of long-standing within a few days, and for the benefit of those who are giving this subject close study, we quote from a building survey published by S. W. Straus & Co. The italics are our own.

"It is to be borne in mind that recent changes in the money market and the heavy liquidation in the stock markets came too late to be reflected in the October building permit records. If these phenomena are to affect the trend of building activities throughout the nation, they *may begin* to show such effects in the November records. The view seems to be quite generally held in the industry that better conditions are in prospect but such a readjustment, if it comes, will not come speedily and there may be no reflection of improved conditions in the November reports. Inasmuch as the first indication of a changing tendency will manifest itself in the building permit index, these data during the next few months will be awaited with unusual interest.

"Recognition is given to the fact that the scope of building operations will for some time to come have a pronounced reaction on the country's general business situation. Other lines, notably the automobile industry, have been going at top speed and now in more recent weeks have shown slower tendencies. Meanwhile building operations have been proceeding at a greatly slackened pace. It is strongly to be hoped, therefore, that the building industry will now prove a sustaining influence to general business. There is reason to feel that such will be the case inasmuch as the partial cessation of building work during the last year and a half has created a wholesome fundamental situation. The country could, it is felt, stand a more intensive building program at this time without danger of disturbing the delicate balance of supply and demand."

PRACTICAL PIPING PROBLEMS

Several problems met in the installation, operation and maintenance of reducing valves

by **W. H. WILSON**

Reducing Valves

Problems in Operation and Maintenance

The maintenance and operation of pressure reducing and regulating valves bring out many different problems. There is probably no other class of valves used in pipe work that has as many different conditions to meet and frequently more is expected of a reducing or regulating valve than it can possibly do. Experiences with these valves are interesting and in many cases results have been obtained in the way of automatic and close regulation that merit recognition for the designers, installers and operators.

Reducing valves should be selected carefully for the services they are required to perform and due consideration should be given local and operating conditions. Careful consideration should be given and good judgment used in selecting a location for the connection for the small pressure control or governor pipe for reducing valves having a separate diaphragm chamber. The location of this pipe connection has a decided bearing on the proper working of the reducing valve and the location should be free from steam engine exhaust pulsations or causes of a similar nature. Make sure the pressure control pipe is free from traps and air pockets, especially when it is of unusual length.

Valves used for reducing steam pressure should have the piping connections arranged to prevent an accumulation of condensation water ahead of the valve. Manufacturers of reducing valves should be given all of the information pertaining to the conditions for which the valve is to be used. Make the manufacturer an interested party and state fully all of the conditions under which the valve is expected to operate. State the pressures, temperatures and capacity it has to work with and furnish a drawing or pencil sketch of the proposed installation.

Various Uses for Steam Reducing Valves

There are many uses for steam reducing valves. They are used for reducing and controlling high pressure steam in heating systems. Many industrial plants use exhaust steam as much as possible for their heating load. At the close of regular working periods and days when the plant is not in operation, high pressure steam is supplied to the heating system through pressure reducing valves.

The heating system equipment, as a general rule, is designed for the use of low pressure steam, usually for a maximum pressure of from 5 to 10 lb. and in many cases economical and satisfactory results can be obtained by a pressure of ½ lb., high pressure steam being used for heating when exhaust steam is not available.

Fig. 1 shows a plan of the installation of steam reducing valves arranged to meet the conditions for a large industrial plant heating load, for example, a heating system of 200,000 sq. ft. of direct radiation, a large battery of lumber drying kilns and other steam for process work.

During regular working hours a large amount of exhaust steam is available. At the close of the regular working hours, in mild weather, the demand for makeup live steam is slight, while on the contrary, during extreme cold weather, this demand increases greatly. It is difficult for a reducing valve to meet these extreme conditions satisfactorily, and for this reason, two separate steam reducing valve units are shown, a two-stage reduction for each unit being used. One is a small size unit for moderate weather or summer conditions and the other, a large size unit for cold weather while both units may be put in operation for emergency use when sub-zero temperatures prevail, or when there is an unusual demand for steam.

The main steam supply is shown in Fig. 2 at A and in order to keep the reducing valves free from condensation water, and the destructive effects of entrained water on the reducing valves, a good, reliable steam trap should be installed, as shown at E.

A strainer and sediment trap is shown at F to protect the steam trap. A full size strainer is sometimes installed in the main steam supply line near the inlet of the reducing valves to prevent pipe scale, pieces of gaskets etc., from damaging the interior parts of the valves. This is good practice and may be the means of preventing injury to expensive valves.

A piping connection for forcing lubricating oil into the interior of reducing valves at frequent intervals will protect and insure better working of the valves. In case reducing valves get out of order, especially at hours when repair men are not at hand, a full size pass-by connection is shown, so that, as an emergency measure the operator can use the pass-by valve, shown at K, Fig. 1, as hand control. As this valve will have to be adjusted by hand, so many turns open to furnish the desired amount of steam, the valve selected for this purpose should be a well made valve of the globe type, or if installation conditions warrant, an angle valve with a guiding spindle on the interior valve disc. This will keep the disc in place when the valve is in operation and protect the valve

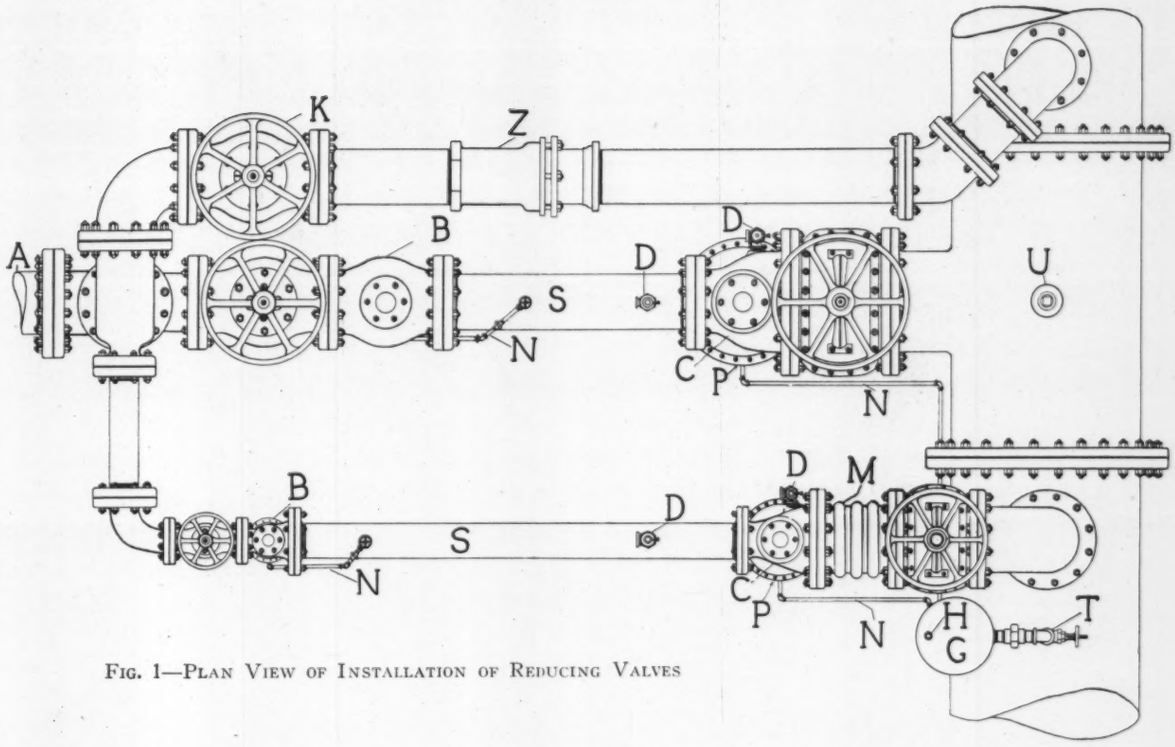


FIG. 1—PLAN VIEW OF INSTALLATION OF REDUCING VALVES

disc from injury from pounding, on account of being used as a throttling valve.

A spring loaded valve is shown at B, Fig. 2, for the first reduction from the initial or primary pressure to the secondary or intermediate pressure and the weight loaded valves are shown at C, Fig. 2, for reducing from the intermediate pressure to the low pressure. Large size diaphragm chambers are shown at P on the regulators for operating on very low pressures.

Gate valves are shown on the outlet side of each unit so that in connection with the inlet valves also shown, each unit may be shut down for repairs without interfering with the other unit or the pass-by connection.

As a matter of precaution against excessive pressure building up on the outlet side of the regulators, in case regulators get out of order or one of the gate valves is left closed, each reducing or regulating valve is provided with a suitable relief valve, shown at D, Fig. 2. The manufacturers, when requested, will provide a tapping in the side of large, low pressure reducing valves that can be used for the location of the relief valve, it being understood that this location will be in the outlet chamber of the valve.

The relief valves shown are of the screwed outlet pattern. In case the escaping steam would be objectionable, or likely to cause damage, it can be piped to a place where it would not cause trouble. The lift lever on each valve is for testing the valve, which should be done at regular intervals.

All gate valves shown are of the rising stem pattern. It is essential that the operator can tell at a glance, positively, that the valves are either open, partly open or closed. This is especially necessary in case of the valve controlling the pressure control pipe connection at the steam main as shown at T, Fig. 2. This valve must be open when either reducing valve is in operation. Should this valve be closed when the reducing valves are in use, the reducing valve will stop reducing and regulating and the pressure will rise on the delivery side of the valve, as there will be no way for the controlling pressure to get to the diaphragm and close the valve.

The water reservoir for the pressure control pipes is shown at G, with the air vent at H, Fig. 2. One water reservoir is used and each reducing valve control pipe is taken from this water reservoir.

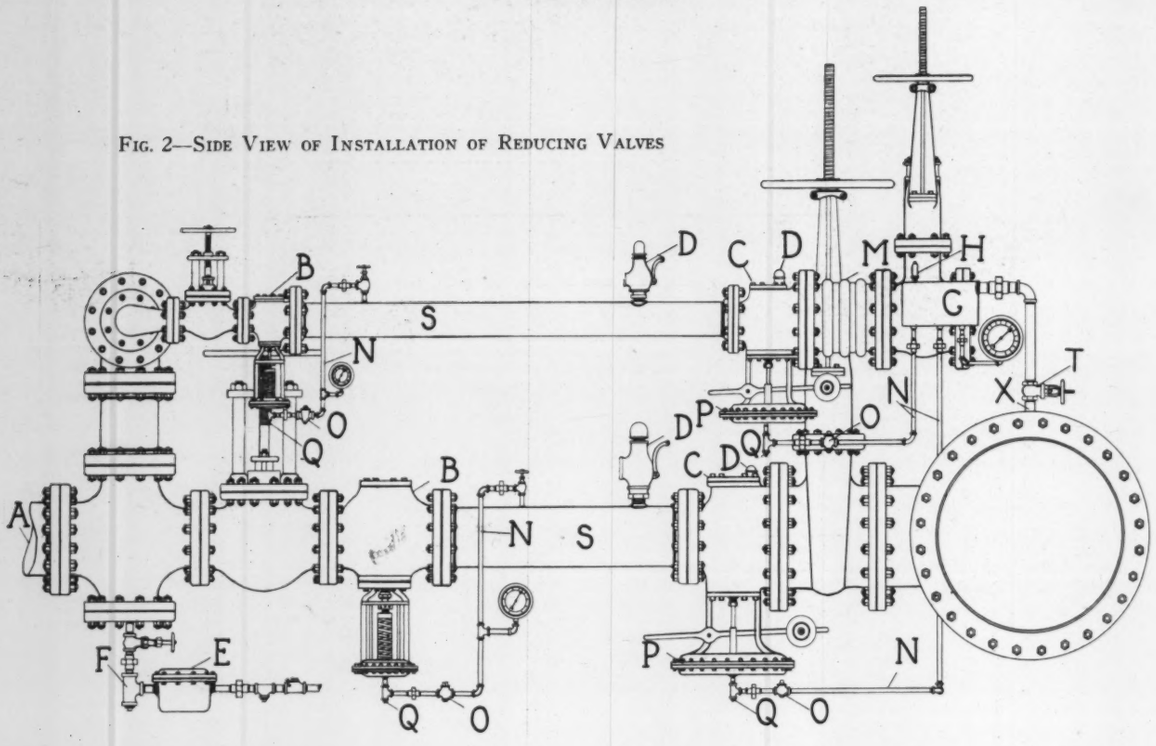
Location of Pressure Gauge

The pressure gauge for indicating the low pressure is shown attached to this reservoir where it gets the benefit of a water seal. This location for the pressure gauge may be altered. If more convenient the gauge can be placed directly on the large steam main. The gauge should be placed where it is convenient for the operator and maintenance men to observe the pressure readings even if it is necessary to pipe it some distance away. Gauges for indicating very low steam pressures should be of the type with compound graduation, 15 lb. pressure, 30 inches vacuum. The zero mark will be at the top of the gauge for this graduation.

Be sure the gauge is provided with a water seal to protect the tube inside of the gauge, from the heat of the steam. If the piping to the gauge has any appreciable length of vertical piping, containing a constant water seal, the gauge must be adjusted for this weight of water, in order to indicate the correct pressure in the steam main.

The pressure control or governor pipes, for the reducing valves are shown at N. The control pipes are each provided with a square head stop cock, as shown at O, Fig. 2, that can be partially closed in case the

FIG. 2—SIDE VIEW OF INSTALLATION OF REDUCING VALVES



reducing valves are not working steadily. This stop cock may be throttled to eliminate the jumping or pulsating motions of the valves.

A tee, with a drain plug, is shown at Q. This plug should be removed occasionally and the sediment drained out of the diaphragm chamber and blown out of the small piping. Ground joint box unions are provided on the pressure control piping so that in case of repairs it can be conveniently and quickly disconnected and laid aside.

A Time Saver in Replacement Work

In removing old diaphragms and when inserting new ones, it frequently happens that the small bolts and nuts used on the diaphragm chambers become badly corroded and difficult to remove. In order to save time in this replacement work, as weather conditions sometimes make it advisable to get the reducing valve in operation as soon as possible, it is recommended that brass or bronze nuts for the bolts be used for assembling the diaphragm chambers.

Reducing valves for reducing by stages and installed in series or tandem, as shown, should have a receiver between the valves. This can be a section of pipe as shown at S, Fig. 2. The pressure control pipes for the reducing valve of the first stage are connected to this receiver.

For large low pressure steam mains, a low pressure, large capacity, non-adjustable relief valve should be applied to protect the piping in case the pass-by valve K, Fig. 1, is opened too freely. This relief valve is shown at U, Fig. 1.

The pressure control pipe connection for the low pressure reducing valves should be located at a point where it is possible to get a steady pressure, free from exhausts from engines or other pulsations, as the working of the reducing valves depends largely on the location of this connection. If it can be done conveniently, carry it some distance away from the reducing valve outlet. Keep the pipe free from traps and air pockets and put the water reservoir at its highest point.

The nipple at the steam main for the pressure control pipe connection, shown at X, Fig. 2, should not extend through the wall of the pipe into the interior of the steam main, as a flow of steam through the large pipe is likely to affect the pressure in the pressure control piping, governing the action of the reducing valves. The end of this nipple should be flush with the inside of the steam main.

Expansion Joints

When the reducing valves are installed as shown, the piping connections will be somewhat rigid unless expansion joints are used—for this reason, a standard type of slip joint is shown at Z, Fig. 1, in the pass-by connection; and a corrugated metal type is shown at M, Fig. 1, on the smaller size reducing valve connection. The manufacturers of this type of expansion joint will provide a sleeve with flange on one end to slip inside of this expansion joint in order to have a smooth interior. On account of being placed close to the reducing valve outlet, the sleeve will assure a full flow of steam that will not be affected with eddies due to the corrugations.

The arrangement of reducing valves shown in these figures can be modified to suit existing piping and local operating conditions. If more room is available, move the stop valves controlling the steam to the inlet of the primary reducing valves farther from the reducing valves.

Some manufacturers of reducing valves insist upon this. The receivers, S, Fig. 2, between the reducing valves should be of ample size to assure a full supply of steam at a steady pressure which will aid in obtaining a steady control for the low pressure regulation.

INTERVIEWS OF INTEREST

Air Environment

What we want from our air environment is health. What we call health is the ability to undertake and carry through to completion anything we need to do, with energy to spare at the finish. The air factors of health will not be universally operative so long as the principles of air conditioning are secretly developed by one esoteric group, and the physiological data are cherished as the sole prerogative of another. It promises much for future harmony, however, when conflicting health data are correlated by men like Dr. Charles Sheard, head of the physical and biophysical research of the Mayo clinic and Mayo foundation, Rochester, Minn. He occupies a middle field between medical and engineering science and is open alike to the unprejudiced consideration of the findings of either group. He writes much, and is given neither to hedging nor over-statement, and he creates no ambiguity about the practical application of the principles he advocates.

Human Response to Air Conditions

"Two things stand out after an exhaustive study of the subject of human response to conditions in the air environment," states Dr. Sheard: "First, the amazing sensitivity of the human organism to slight changes in air conditions; and second, the allowance that must be made for the effect of acclimatization.

"The normal temperature of the body is about 98.6 deg. fahr. The body is a heat producing engine and must continuously lose its heat so that body temperature will not be elevated above this point. The ideal indoor temperature ranges between 65 deg. and 70 deg. fahr. with sufficient air movement to create a condition of comfort without a sense of draft.

"These correlations are matters of common knowledge. They are not matters of common practice. Colds follow upon any failure of body readjustment when the skin of an overheated body is exposed to sudden cold. The medical facts involved are rather intricate, but the facts can be generally understood when the rise of nose and throat infection can be consistently traced to the vasomotor effects of sudden chilling of skin which has been subjected to dry and overheated air. The home is prone to overheat. The season of colds begins with furnace heat. It is poor economy and a poor health measure to maintain our heat bone dry.

Acclimatization

"This is one side of the picture. The acclimatization factor is such that people call comfortable the particular condition to which they have become accustomed. The skin is the natural thermostat of the body. It controls to great degree the distribution of blood to the different parts of the body. It loses tone in humid heat.

"Factors of acclimatization are such that they invalidate much accepted physiological data on air conditions. Statistical estimate of ventilation efficiencies often tell more about individual habit and propensity than it does with respect to absolute comfort norms. When physiological depression finds relief in higher altitudes, who is to say whether the beneficial effect is due to the relative purity of the air that is breathed, its freedom from specific dusts, its low oxygen content, its stimulating temperature, its low humidity, or to its content of ozone? Heliotherapy enthusiasts claim it may be the effects of light alone.

"Improved apparatus and more careful application of air hygiene cure many ventilation ills. Interest centers now upon human physiological reaction for the measure of positive factors for health. One laboratory is said to have manufactured air that is better than normal air for experimental animals.

"We know that bad dispositions impinge very definitely upon such matters as the presence of low blood calcium or high blood sugar. We know that whole sunlight on the skin in some degree acts similarly upon the human organism to energizing foods. Are polarized air atoms essential, too? —S. P. M.

Conventions and Expositions

American Society of Mechanical Engineers: Annual meeting, Dec. 2-6, New York. Secretary, Calvin W. Rice, 29 W. 39th st., New York City.

American Society of Refrigerating Engineers: Annual meeting, Dec. 2-6; New York. Secretary, David L. Fiske, 37 W. 39th st., New York City.

National Exposition of Power and Mechanical Engineering: Week of Dec. 2. Grand Central Palace, New York City.

American Society of Heating and Ventilating Engineers: Annual meeting, Jan. 27-31, Philadelphia. Secretary, A. V. Hutchinson, 29 W. 39th st., New York City.

International Heating and Ventilating Exposition: Jan. 27-31, Commercial Museum, Philadelphia. In connection with A. S. H. V. E. annual meeting.

American Institute of Electrical Engineers: Annual winter convention, Jan. 27-31, New York. Secretary, F. L. Hutchinson, 33 W. 39th st., New York City.

National Industrial Exposition: Mar. 3-7, Hotel Stevens, Chicago.

American Oil Burner Association: Annual convention, April 7-12, Hotel Stevens, Chicago.

World Power Conference: June 16-25, Berlin. Program Committee, Room 1818, 29 W. 39th st., New York City.

Stoker Manufacturers Association: Nov. 11-13. Greenbrier Hotel, White Sulphur Springs, West Virginia.

Maccabees Building, Detroit

The Maccabees Building in the city of Detroit, illustrated below, was built to accommodate 2,000 occupants. It requires a total radiation of 65,000 sq. ft., 35,000 sq. ft. of which is direct radiation and 30,000 indirect radiation. On the second and third floors both direct and indirect radiation are used, controlled by thermostats. The first to the fourteenth floors inclusive have direct radiation with window ventilation. The auditorium in the building is air conditioned, the heat being supplied with indirect fin type radiation.

Recent Trade Literature

Boilers: Heating Systems Corp., Joliet, Illinois; four page pamphlet on welded steel boiler; circular on oil burning warm air heater.

Boilers: American Radiator Co., New York City; a hand-book dealing with pertinent facts concerning gas fired boilers.

Electrical Equipment: General Electric Company, Schenectady, N. Y.; data sheets on magnetic controllers for constant speed motors and for wound-rotor, induction motors.

Furnaces: The General Iron Works Co., Cincinnati; four page pamphlet on heating and ventilating unit.

Gauges: The Foxboro Company, Foxboro, Mass.; circular on recording gauges.

Humidifying: American Moistening Company, Providence, R. I.; four pages on control of humidity. Bulletin on electric humidity control. Monthly booklets describing textile mills throughout the country.

Insulation: The Korfund Co., Inc., New York City; a publication devoted to the study and application of soundproofing of buildings and the isolation of machine vibration.

Piping: The Linde Air Products Company, New York City; a twenty-four page booklet dealing with oxy-acetylene welded pipe for industrial plants and for domestic heating systems. Information on welded pipe for the transportation of oil, gas, chemicals and water is also included.

Piping: Tube-Turns, Inc., Louisville, Ky.; an attractive bulletin on the pipe welding with stock fittings in the power plant of the Bureau of Standards.

Pressure Control: General Electric Company, Schenectady, N. Y.; data sheet on a pressure governor for use with automatic starters on motor-driven pumps or compressors to maintain a constant pressure on liquid or gas systems.

Radiators: Heintz Manufacturing Company, Philadelphia; a bulletin on a new cabinet radiator.

Radiators: Shaw-Perkins Manufacturing Company, Pittsburgh; thirty-two page catalog on oval tube radiation for steam and hot water heating and cooling, drying and industrial applications. Tables of dimensions and heat emission are included.

Radiation: The York Heating and Ventilating Corp., Philadelphia; a catalog on fan blast radiation which is said to contain information on that subject unobtainable elsewhere. This company has also published a catalog on heat diffusing units.

Unit Heaters: Buffalo Forge Company, Buffalo, N. Y.; a bulletin on a new heater that washes and humidifies the air.

Unit Heaters: The Columbus Heating & Ventilating Company, Columbus, Ohio; an eight page bulletin on gas-fired unit heaters for industrial use. Topics covered include insulation and operating economy, features of operation, and a table of capacities.

Unit Heaters: The Buckeye Blower Company, Columbus, Ohio; a folder on the large capacity, high velocity, industrial unit heater containing drawings of the various units and tables of capacity.

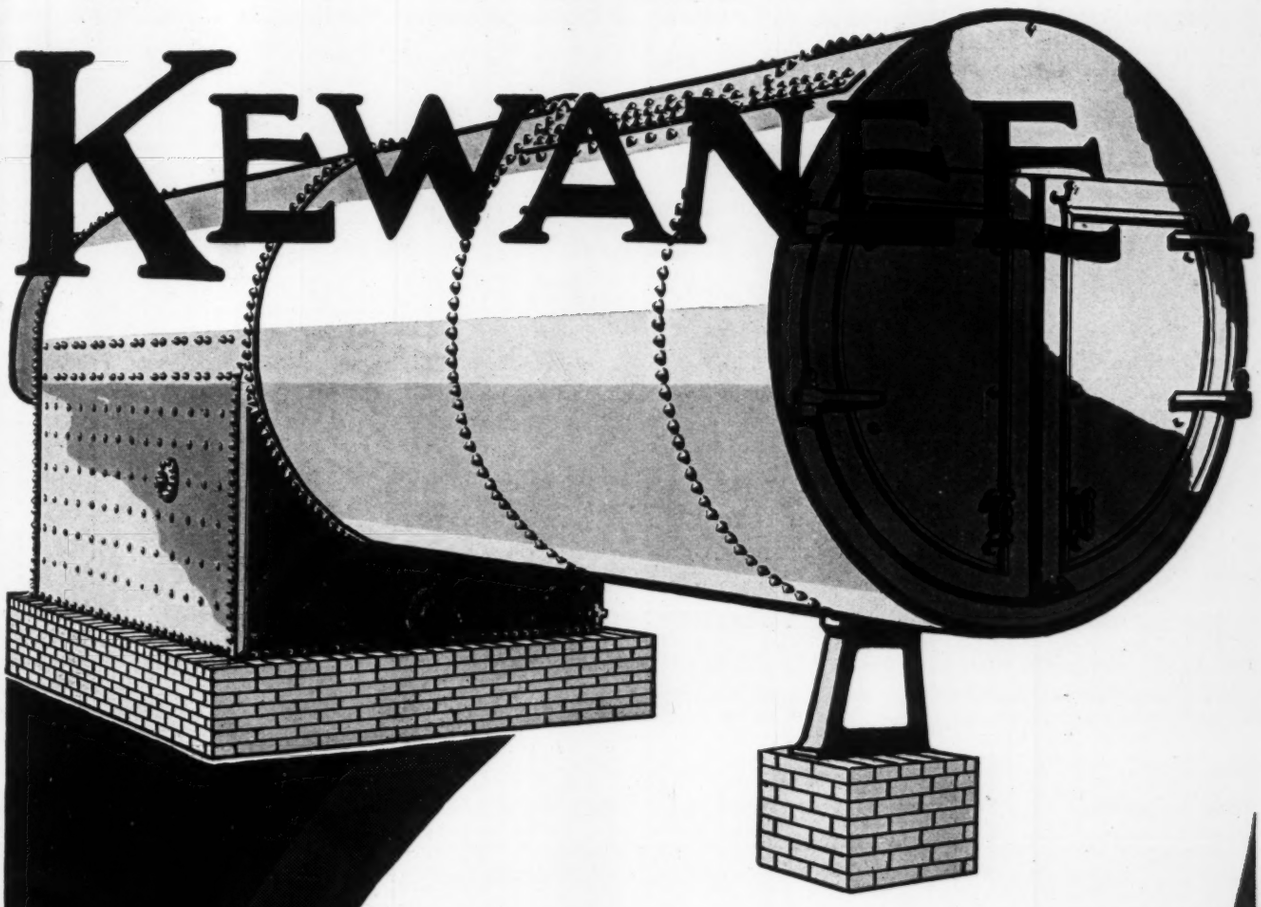
Unit Heaters: B. F. Sturtevant Company, Boston, Mass.; three booklets—one giving data on the heaters for architects, engineers, contractors, and owners, another containing tips on heater selling and the third, information on the distinctive features of this company's product.

Valves: Cochrane Corporation, Philadelphia; a folder on the new back pressure valve made by this company.

Valves: Gorton Heating Corporation, New York City; a bulletin on air valves for oil burning, steam heating systems.

Welding Sets: General Electric Company, Schenectady, N. Y.; data sheets on constant potential arc-welding sets. These sets are especially adapted to automatic welding. Also a data sheet on an automatic welding head and control, magnetic clutch type.

Welders: The Lincoln Electric Company, Cleveland, Ohio; specification bulletins on the three hundred ampere arc welders made by this company.



Two savings are built into every Kewanee Boiler . . .

The unusual strength and dependability of its steel-riveted construction adds many *extra* years to its life—reducing the cost-per-year-of-service to a very low figure.

And a Kewanee *saves fuel every year of its existence.* Boilers can be bought for less but they can't provide the same years of service, nor the same economy in the use of fuel, so in the end they actually cost more.

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For every need!

For more than forty years Warren Webster & Company, pioneers of the Vacuum System of Steam Heating, have kept well in advance of the growing diversity of demand for heating service, with a Webster System specifically adapted to every individual heating need or problem.

Today this standard—*a Webster System specifically adapted to every heating need or problem*—gains a new significance . . . Now you can select from *four* basic Webster Systems—each built to meet certain conditions; each a combination of service, experience, equipment and engineering methods varied to meet the heating requirements of the individual installation.

Be sure to see the newest developments in Webster Systems at the New York and Philadelphia Expositions.

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Branches in 52 principal U. S. Cities
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See these Exhibits

NEW YORK

Exhibit of Webster Systems of Steam Heating at the New York Power Show, Grand Central Palace, December 2nd to 7th, 1929, Booths 225 and 226.

PHILADELPHIA

Exhibit of Webster Systems of Steam Heating at the International Heating and Ventilating Exposition of the American Society of Heating and Ventilating Engineers, Commercial Museum, 34th below Spruce Street, Philadelphia, January 27th to 31st, 1930, Booths 754, 755, 758 and 809.

SHOWING

Webster MODERATOR System of Steam Heating, the "Controlled-by-the-Weather" System for large buildings.

Standard Webster Vacuum System of Steam Heating.

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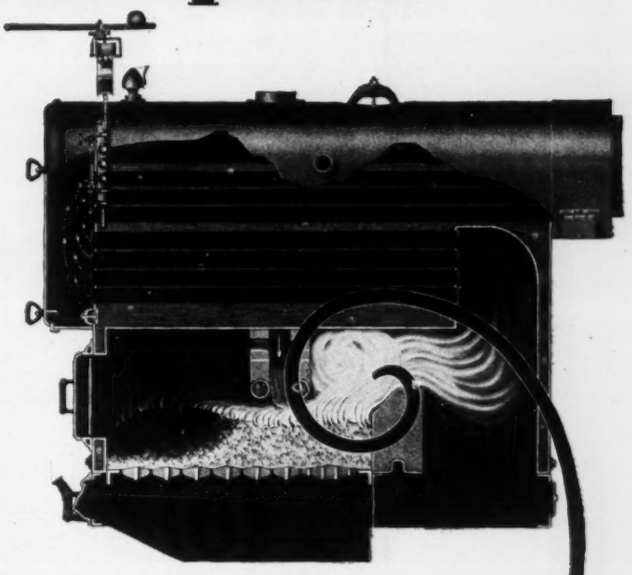
Systems of Steam Heating

HEATING, PIPING and AIR CONDITIONING, Published monthly by Engineering Publications, Inc., 1900 Prairie Ave., Chicago, Ill. Subscription rates: $3.00 per year, anywhere in the world; single copies: 50 cents. Back numbers: $1.00. December, 1929, Vol. 1, No. 8. Entered as Second Class Matter May 18, 1929, at the Post Office at Chicago, Illinois, under the Act of March 3, 1879.

No Smoke Passes This Whirlpool!

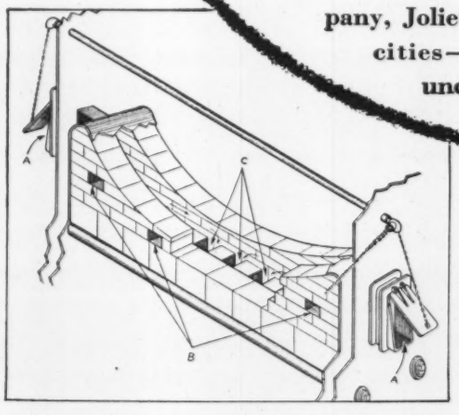


Like dry tinder—the soot laden gases of soft coal ignite the instant they strike this turbulent whirling mass of incandescent flame!

They burn and their usable heat units are utilized—because in this new Heggie-Simplex Smokeless Boiler there is always the right amount of oxygen to effect complete combustion. The additional oxygen necessary to burn bituminous coal smokelessly, but which can not be drawn through the fuel bed alone, is introduced through a special "carbureting chamber" over the fire.

Built of refractories, this chamber not only introduces the necessary additional oxygen but thoroughly heats it before passing it down onto the fire. A refractory bridge wall to the rear of this chamber baffles the fire, creating a whirlpool of flame which consumes all of the smoke and combustibles.

For complete facts, write Heggie-Simplex Boiler Company, Joliet, Ill.; representatives in principal cities—telephone and address listed under "Heggie-Simplex Boilers."



The "Carbureting Chamber" of the Heggie-Simplex Smokeless Boiler

Air is drawn in through intake doors (A) on both sides of the boiler. Volatiles arising from the fresh fuel are admitted through ports (B) in the forward wall. This inflammable mixture is thoroughly heated by the hot refractory walls of the chamber. It is ready for instant combustion when it passes through the jets (C) to mix with the gas stream flowing under the chamber.

Note there are no bothersome ceiling pulleys, long chains, etc. The operating device is "built in" the boiler.

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STEEL HEATING BOILERS

PITKIN THEATRE, BROOKLYN, N. Y.

Architect and Engineer: Thomas W. Lamb *Heating Contractor:* Thompson Starrett Company

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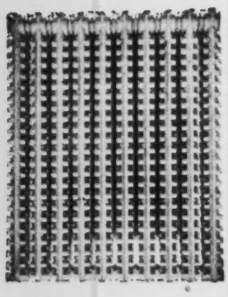
New Theatre selects dependable VENTO

CAST IRON HEATERS

THERE is no building in which Vento Cast Iron Heaters can do a better job than in a theatre. Here, where people are congregated in close proximity, where their comfort means money in the pocket of the owner, a perfect ventilating and heating system is absolutely necessary. That is why Vento was selected to furnish warmth and ventilation in Loew's Pitkin Theatre in Brooklyn.



Typical stack of VENTO

For over 25 years, Vento has been endorsed by the world's leading heating engineers and architects. During that time the millions of square feet of Vento in constant operation have maintained a perfect record.

The superior cast iron from which Vento is made gives it almost unlimited life. And its unique design and construction insures rapid circulation of steam and breaks up the air currents causing the most intimate contact of air with heating surfaces so that it gives much greater heating efficiency.

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AMERICAN RADIATOR COMPANY

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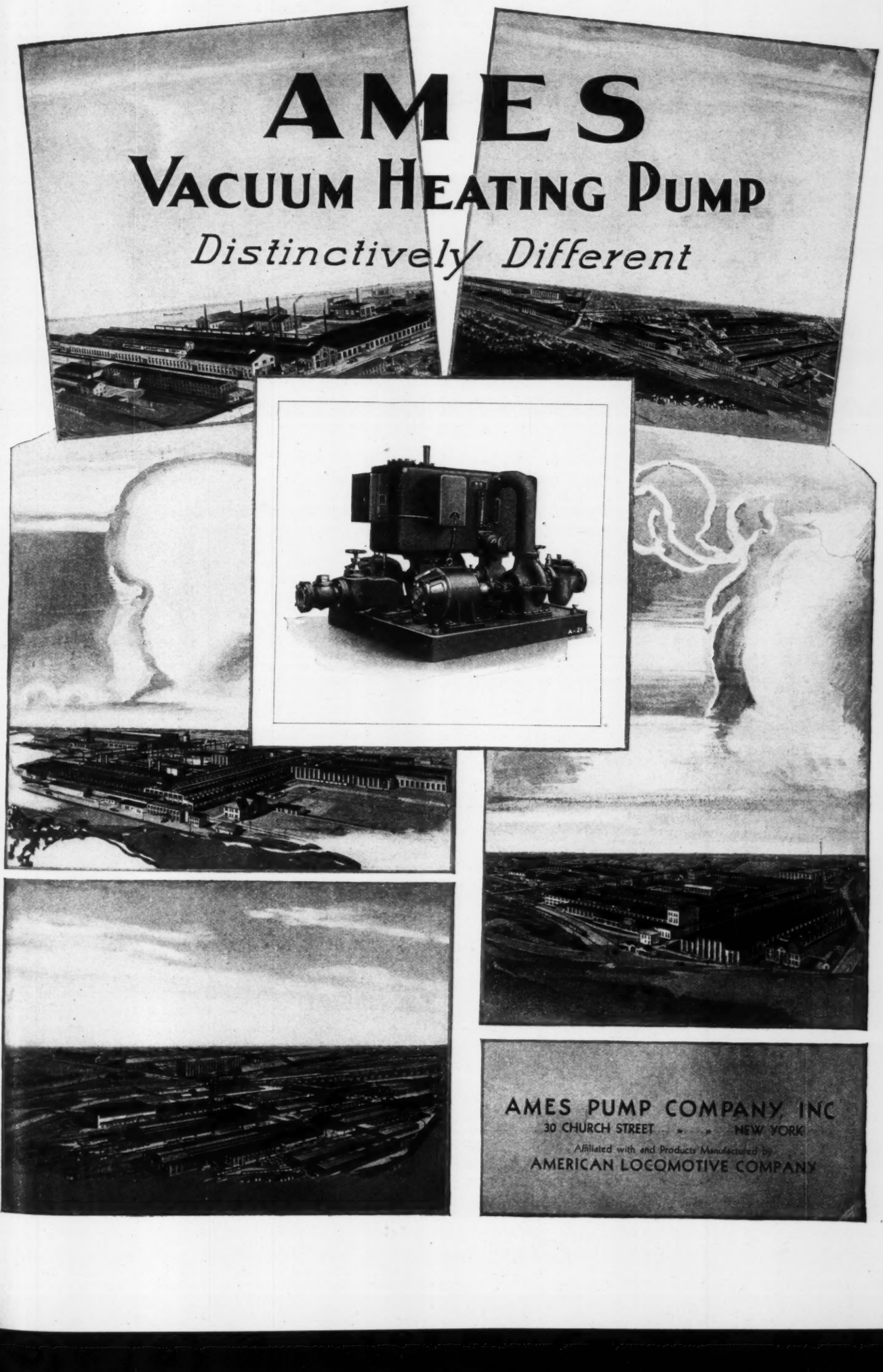

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MODERN PIPING FOR THE

SEE IT AT THE POWER SHOW BOOTHS 221 and 222

THE power plant, industrial process and oil refinery of today all make demands upon piping—and particularly upon the joints—unknown only a few years ago.

That Midwest has kept pace with these requirements—in fact, that Midwest has anticipated tomorrow's requirements is evident from the few photographs shown here. The Midwest exhibit at the Power Show will tell the story more completely. You are invited to see it.

MIDWEST PIPING & SUPPLY CO. INC

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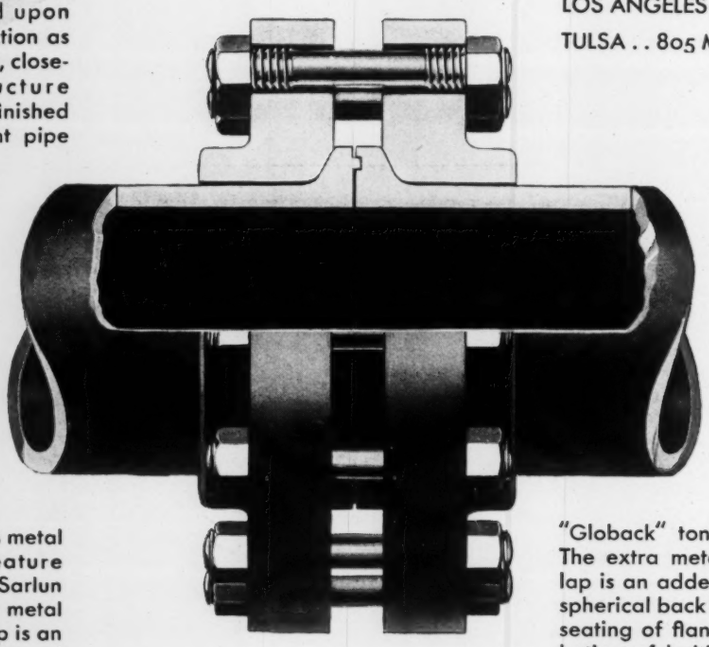
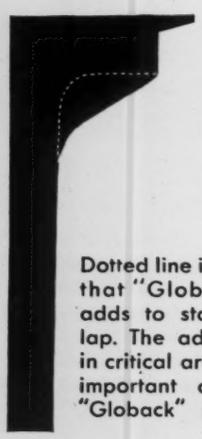
Photo of finished "Globack" Van Stone lap double-printed upon photo of lap section as rolled. A uniform, close-grained structure throughout the finished lap and adjacent pipe wall is assured.



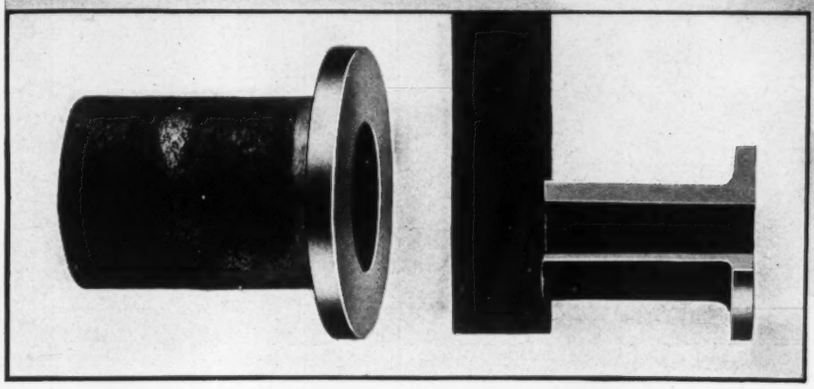
"Globack" tongue and groove joint. The extra metal in critical section of lap is an added factor of safety while spherical back faces of laps assure fair seating of flanges and uniform distribution of bolting pressure. Maximum bolting stress is removed from periphery of laps.



Dotted line indicates metal that "Globack" feature adds to standard Sarlun lap. The additional metal in critical area of lap is an important advantage of "Globack" joints.

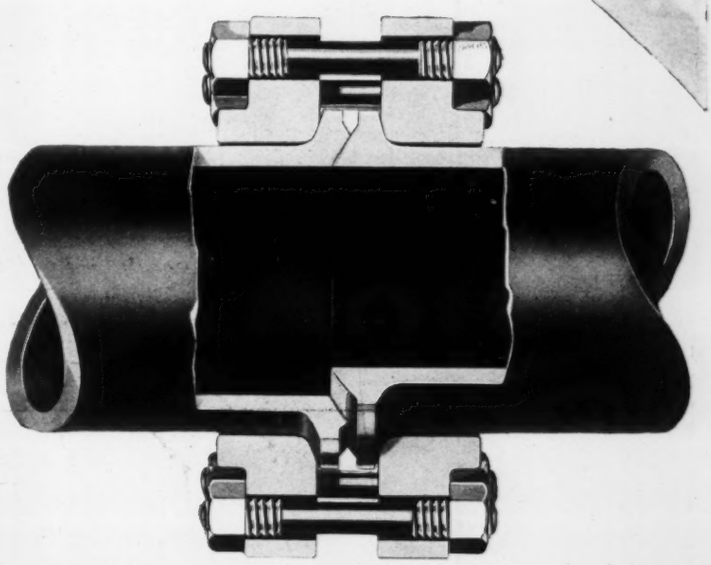
A GREATER MIDWEST

MODERN POWER PLANT



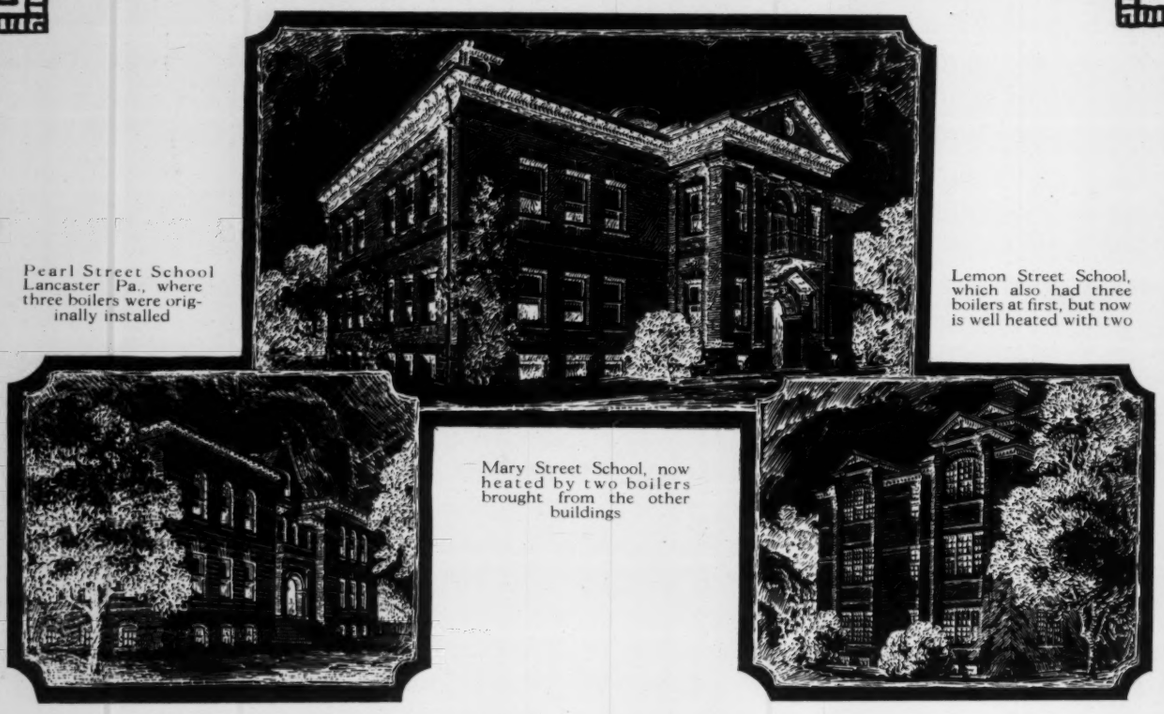
Unretouched photo of section cut from Van Stone lap rolled by Midwest. Note the increased thickness, large radius fillet and square corner.

Midwest has perfected a special process for applying Van Stone laps to small pipe sizes. This photo shows ½" and 1" extra heavy pipe. After machining front and back, lap is full pipe wall thickness, corner is square, and radius of fillet is large.



Midwest Joint requires neither gasket nor field welding. All lap and flange contact surfaces are spherical so piping need not be in accurate alignment and bolting pressure is more uniformly distributed. Laps are heavier than pipe wall thickness.

PIPING SERVICE



Pearl Street School Lancaster Pa., where three boilers were originally installed

Mary Street School, now heated by two boilers brought from the other buildings

Lemon Street School, which also had three boilers at first, but now is well heated with two

One Boiler Does the Work Assigned to Three In These Lancaster, Pa., Schools

IN planning heat for two school buildings at Lancaster, Pa., three Burnham cast iron sectional boilers were assigned to each school. Two for heating. One for reserve.

In actual operation, one of these 50-inch steam boilers heated each of the schools. Which meant one for heating and two in reserve.

So one of the boilers in each school was taken out, and the two boilers were used to heat a third school building, with complete satisfaction all 'round.

The engineer had followed the usual sound practice, but he failed to take into account the unusual heating efficiency of Burnham cast iron boilers, due to their extra length of fire travel and other features.

Write for catalogue giving full descriptions, ratings and measurements of Burnham Boilers for every heating purpose.

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MARSH Heating Specialties

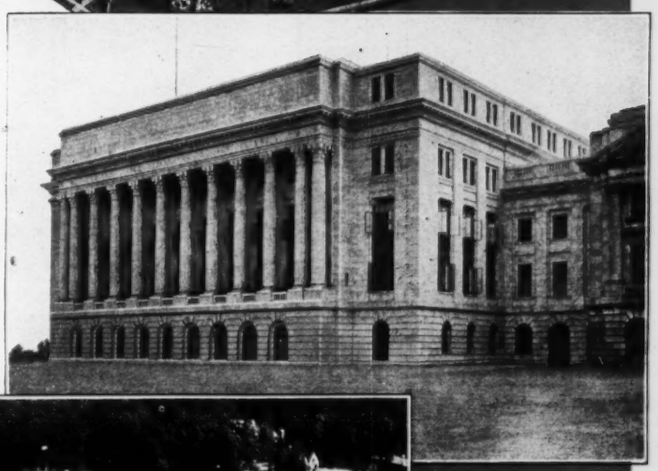
IN WASHINGTON — the home of our National Government, where beautiful residences, attractive apartments and stately Federal Buildings abound; where living is regarded as an art — there MARSH Heating Specialties do their share in providing heating comforts to the occupants, at low operating costs to the owners.

Of the many recent MARSH installations in Washington, we show here examples of three outstanding types.

The Hampshire Garden apartments — an unusually fine and beautiful development — 100% co-operative. MARSH equipment used throughout the entire group of buildings.

HAMPSHIRE GARDEN APTS., Shapiro Const. Co., Bldg. Contrs., Geo. T. Santmyers, Archt

The New Department of Agriculture — one of the many outstanding Federal buildings in which MARSH Heating Specialties have been installed during the past few years.



The Wardman Park Hotel Group. In a new addition to this fine example of Washington Hotel Apartments, MARSH Specialties were installed a year or so ago. Because of the very satisfactory and economical operation of this installation, the entire group of buildings is being refitted this year with MARSH Heating Specialties.

As in Washington, so in all big cities throughout the country — MARSH Heating Systems and Specialties stand supreme. Architects and Contractors are invited to send for bulletins and to avail themselves of Marsh Engineering Service.

Above
FEDERAL DEPT. OF AGRICULTURE BLDG.
Standard Engineering Co., Heating Contractors, Plans by Supervising Architect's Office, Treasury Department.

At left
The famously beautiful WARDMAN PARK HOTEL GROUP

JAS. P. MARSH & COMPANY
Division of General Instrument Corporation
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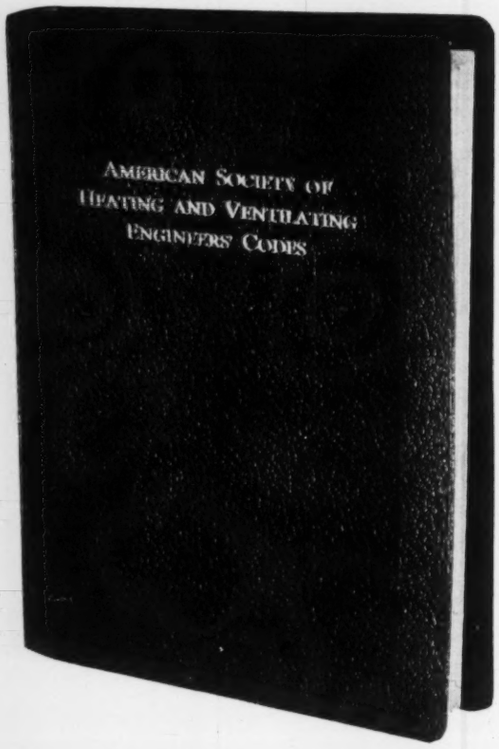

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$5.00 per Copy

The Code of Minimum Requirements—

For the Heating and Ventilation of Buildings

(EDITION OF 1929)

has just been published by the AMERICAN SOCIETY *of* HEATING *and* VENTILATING ENGINEERS, *New York, in fourteen sections, bound attractively in a loose leaf holder.*

The Code in these separate pamphlets is the result of many years effort by L. A. HARDING *and his Committee and as published, is the culmination of five years work.*

Each section was prepared by a Sub-Committee and the following subjects are covered:

Section I Minimum Ventilation Requirements for Public Buildings.

Section II Minimum Requirements for Estimating the Heat Required for Warm Buildings.

Section III Minimum Requirements for the Determination of the Amount of Direct Steam and Hot Water Radiating Surface to be installed in Steam and Hot Water Heating Systems.

Section IV Minimum Requirements for the Determination of the Amount of Indirect Steam or Hot Water Heating Surface to be Installed in Indirect Gravity and Fan Circulation Heating and Ventilating Systems.

Section V Minimum Capacity and Installation Requirements for Low Pressure Steam and Hot Water Heating Boilers.

Section VI Minimum Requirements for the Design and Installation of Warm Air Furnace Heating Plants.

Section VII Minimum Requirements for the Design and Installation of Chimneys or Stacks for Steam Boilers, Hot Water Boilers and Warm Air Furnaces.

Section VIII Minimum Requirements for Pipe Sizes for Use with Low Pressure Steam, Vapor and Vacuum Heating Systems.

Section IX Minimum Requirements for Pipe Sizes for Use with Gravity and Forced Hot Water Heating Systems.

Section X Minimum Requirements for the Design and Installation of Air Ducts, Inlets and Outlets, in Conjunction with Fan Air Circulation, and the Installation of Ventilating Fans for Use with Steam and Hot Water Heating and Ventilating Systems.

Section XI Minimum Requirements for the installation of Air Washers and Filters.

Section XII Pumps for Heating and Ventilating Equipment.

Appendix I Formulae for Physical Units, Air and Vapor Mixtures, Etc

Appendix II Standard Symbols for Heating and Ventilating Drawings.

The Code consists of 158 pages and is fitted into a loose leaf binder with black flexible cover. It is printed on India Tint stock, 6x9 inches in size.

The Code of Minimum Requirements was developed as a result of numerous requests made to the Society by engineers, architects, municipalities, engineering and trade organizations and its purpose is to standardize as far as practical the installation of heating and ventilating equipment.

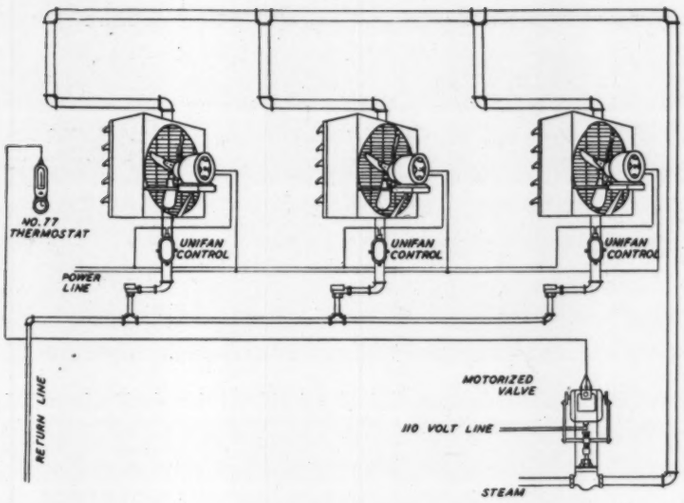
The Code represents minimum requirements as called for by good engineering practice and is so written that it may be incorporated as a part of a Municipal Building Code, if found desirable.

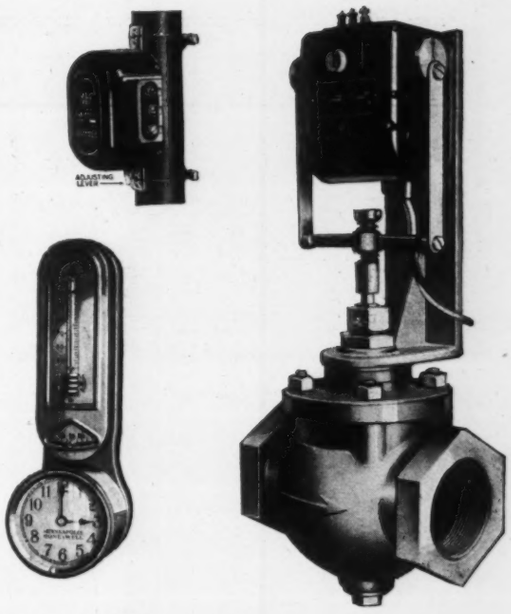
Great credit is due to the men who have given their time unselfishly and the Society is indebted to the Sub-Committee Chairmen who labored so long and earnestly to produce the Code.

The men who assisted Mr. Harding were: E. VERNON HILL, Chicago; A. C. WILLARD, Urbana, Ill.; R. V. FROST, Norristown, Pa.; L. C. SOULE, Newark, N. J.; J. F. McINTIRE, Detroit; J. D. HOFFMAN, Lafayette, Ind.; J. R. McCOLL, Detroit; J. A. DONNELLY, Largent, W. Va.; W. S. TIMMIS, New York City, (Deceased); C. A. BOOTH, Buffalo; W. H. CARRIER, Newark, N. J.; PERRY WEST, Newark, N. J.; F. PAUL ANDERSON, Lexington, Ky. and J. H. WALKER, Pittsburgh.

AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS

29 WEST 39th STREET :-: **NEW YORK, N. Y.**





THE PERFECT Unit Heater Installation Has Automatic Control—

The inherent characteristics of unit heating demand automatic control for most satisfactory and economical operation.

With the fan off and the steam on heat is wasted. This condition exists when room temperatures are up to normal and the fan is turned off. The standby heat losses can be eliminated with Minneapolis-Honeywell "Steam Flow Control"—it turns the steam off on individual units or complete sections of the system, when heat is not wanted.

With the fan on and the steam off, cold air is circulated. This condition occurs when steam has been off or has failed and fan continues to run, or where the fan is started before the unit is up to proper temperature. Minneapolis-Honeywell "Unifan Control" prevents the operation of the fan when the heating element is cold, thus avoiding cold, dangerous drafts.

Minneapolis-Honeywell controls are designed to meet the requirements of all types of installations giving not only automatic but most economical and satisfactory operation of the heating system.

MINNEAPOLIS
INDUSTRIAL REGULATORS
HONEYWELL

MINNEAPOLIS-HONEYWELL REGULATOR COMPANY
Executive Offices: 2701 Fourth Ave. So., Minneapolis, Minn.
Factories: Minneapolis, Minn. and Wabash, Ind.
Branch Offices: New York, Chicago, Philadelphia, Boston, Detroit, Cleveland, St. Louis, Milwaukee, Pittsburgh, Washington, Buffalo, Syracuse, Rochester, Denver, Los Angeles, San Francisco, Portland, Seattle, Hartford, New Haven.

MINNEAPOLIS-HONEYWELL REGULATOR CO.,
2701 Fourth Ave. So., Minneapolis, Minn.

☐ Send me your pamphlet on Unit Heater and Sectional Control Systems.

☐ Have representative call. I understand there is no obligation.

Name..... Position.....
Company.....
Address.....
City..... State.....

The Dunham Differential Vacuum Heating System

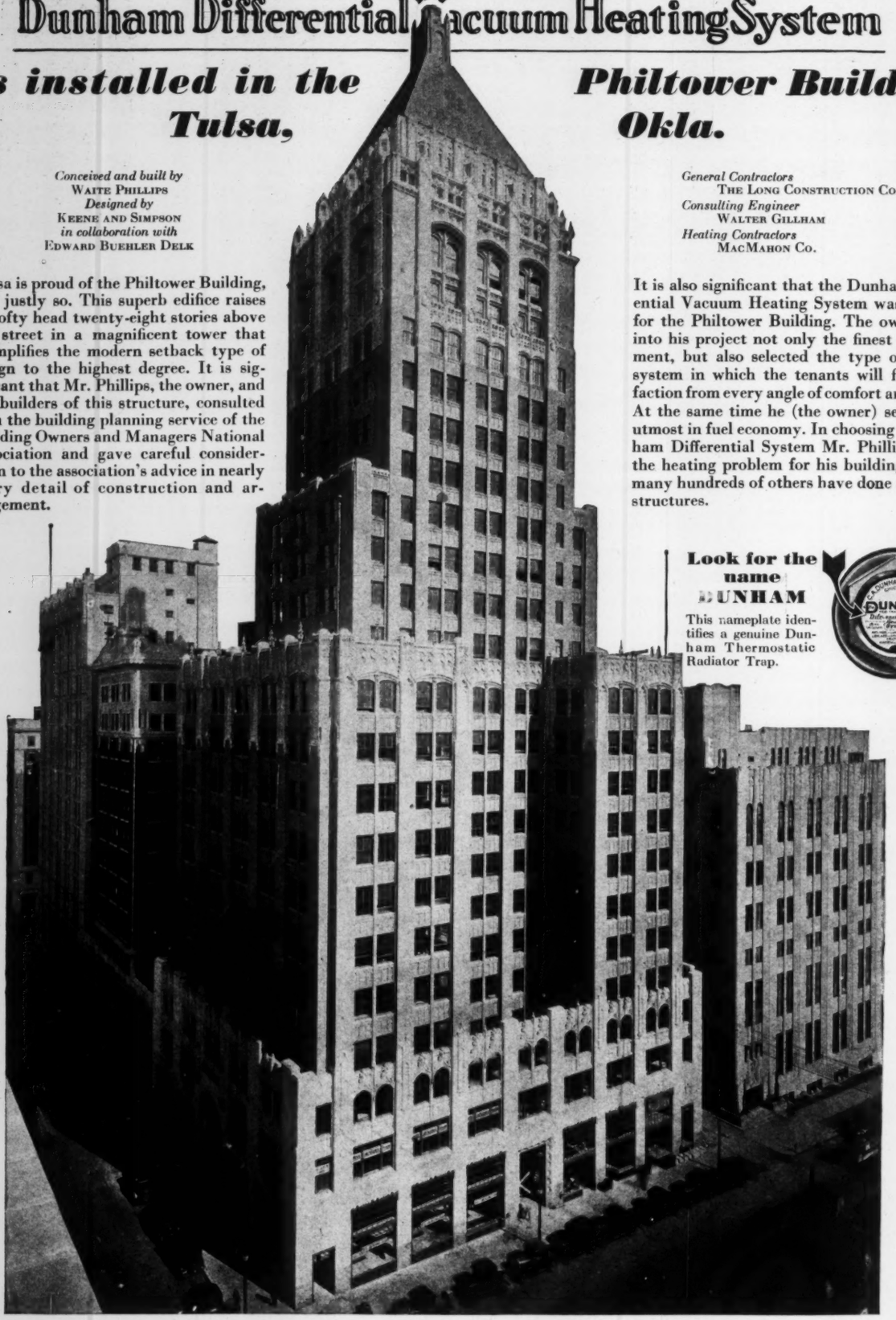
is installed in the Philtower Building Tulsa, Okla.

Conceived and built by
WAITE PHILLIPS
Designed by
KEENE AND SIMPSON
in collaboration with
EDWARD BUEHLER DELK

General Contractors
THE LONG CONSTRUCTION COMPANY
Consulting Engineer
WALTER GILLHAM
Heating Contractors
MACMAHON CO.

Tulsa is proud of the Philtower Building, and justly so. This superb edifice raises its lofty head twenty-eight stories above the street in a magnificent tower that exemplifies the modern setback type of design to the highest degree. It is significant that Mr. Phillips, the owner, and the builders of this structure, consulted with the building planning service of the Building Owners and Managers National Association and gave careful consideration to the association's advice in nearly every detail of construction and arrangement.

It is also significant that the Dunham Differential Vacuum Heating System was selected for the Philtower Building. The owner built into his project not only the finest of equipment, but also selected the type of heating system in which the tenants will find satisfaction from every angle of comfort and health. At the same time he (the owner) secures the utmost in fuel economy. In choosing the Dunham Differential System Mr. Phillips solved the heating problem for his building, just as many hundreds of others have done in similar structures.



Look for the name DUNHAM

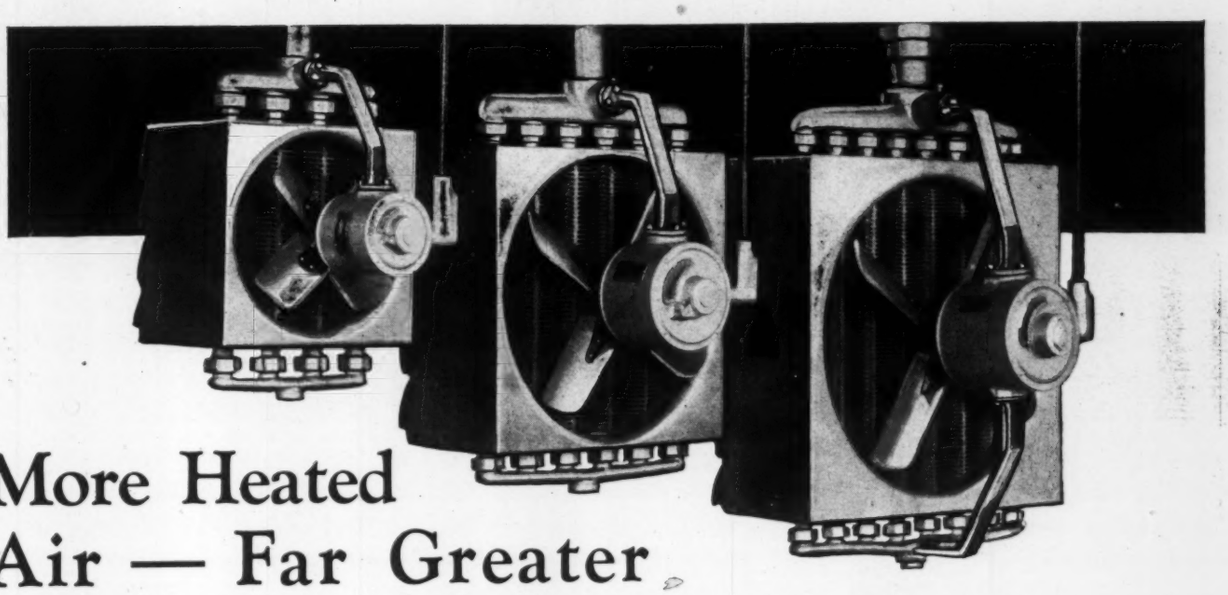
This nameplate identifies a genuine Dunham Thermostatic Radiator Trap.

C. A. DUNHAM CO.

Dunham Building, 450 East Ohio Street
CHICAGO, ILLINOIS

Over eighty sales offices in the United States, Canada and the United Kingdom bring Dunham Heating Service as close to you as your telephone. Consult your telephone directory for the address of our office in your city. An engineer will counsel with you on any project.

The Dunham Differential Vacuum Heating System and individual parts of the apparatus used in that system are fully protected by United States Patents Nos. 1,644,114, 1,706,401 and 1,727,965, and Canadian Patents Nos. 282,193, 282,194 and 282,195. Additional patents in the United States, Canada and foreign countries are now pending.



More Heated Air — Far Greater Diffusion — Much Less Time — per B. T. U. of Fuel Consumed

More heat uniformly and effectively distributed for less money is the reason for a unit heater. And the same reason applies to the Air-Way Unit Heater.

Air-Way claims — and proves — more heated air per minute per B. T. U. of fuel consumed; a far more rapid and complete diffusion in the space to be heated; and a design and construction that absolutely safeguards the system from service troubles.

Air-Way is successfully and economically heating places that present difficulties never before considered as satisfactorily solvable by any heating system known. The tremendous, irresistible volume of heated air pouring from the Air-Way Unit with a velocity unknown to other devices, projected with the exact required trajectory, simply and positively creates and maintains the desired temperature in every nook and corner of any place however vast or exposed. These amazing results are accomplished by Air-Way exclusive design and construction. They are readily provable.

And in addition, you will find that the Air-Way has no connections to become loosened. Hammering of steam and water cannot impair it. Galvanic action cannot weaken it. Freezing will not crack it. Service troubles do not eat up the fuel saving. We will welcome an opportunity to tell you more about Air-Way.

Air-Way
UNIT HEATER

Please send complete information about Air-Way Unit Heaters

Company name.....

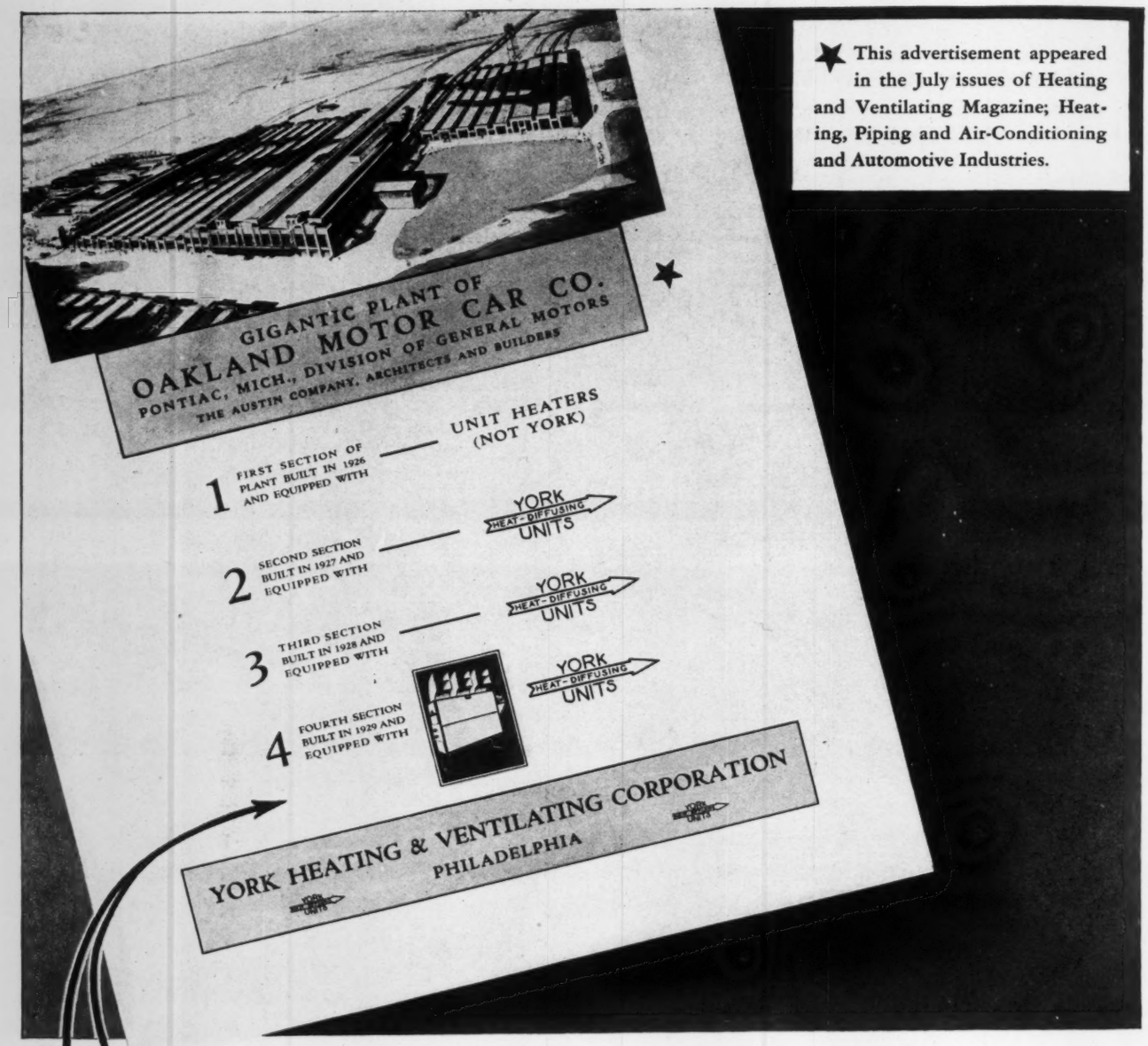
City.....

State.....

Your Name.....

AIR-WAY ELECTRIC APPLIANCE CORPORATION

Heating Systems Division TOLEDO, OHIO


GIGANTIC PLANT OF
OAKLAND MOTOR CAR CO.
PONTIAC, MICH., DIVISION OF GENERAL MOTORS
THE AUSTIN COMPANY, ARCHITECTS AND BUILDERS
1 FIRST SECTION OF PLANT BUILT IN 1926 AND EQUIPPED WITH — UNIT HEATERS (NOT YORK)
2 SECOND SECTION BUILT IN 1927 AND EQUIPPED WITH — YORK HEAT-DIFFUSING UNITS
3 THIRD SECTION BUILT IN 1928 AND EQUIPPED WITH — YORK HEAT-DIFFUSING UNITS
4 FOURTH SECTION BUILT IN 1929 AND EQUIPPED WITH — YORK HEAT-DIFFUSING UNITS
YORK HEATING & VENTILATING CORPORATION
PHILADELPHIA

★ This advertisement appeared in the July issues of Heating and Ventilating Magazine; Heating, Piping and Air-Conditioning and Automotive Industries.

5 ORDERED IN 1929 —— YORK HEAT-DIFFUSING UNITS

6 ORDERED IN 1929 —— YORK HEAT-DIFFUSING UNITS

YORK HEATING & VENTILATING CORPORATION
PHILADELPHIA

THIS BOOK FREE

THIS *new* edition of Stockham's Catalog contains more than 300 pages of useful and helpful information for the fitting buyer and user. The entire Stockham line is described and illustrated. Vest pocket size; bound in imitation leather; conveniently classified and indexed. Former editions are in wide use, but you want the new one. You'll find it mighty handy! Just fill in and mail the coupon . . . *today* . . . the book will reach you promptly.

STOCKHAM PIPE & FITTINGS COMPANY
BIRMINGHAM, ALA.

STOCKHAM PIPE & FITTINGS CO.
BIRMINGHAM, ALABAMA

Please send me a copy of STOCKHAM FITTINGS CATALOG "H."

Name_____

Street_____

City_____ State_____

WHAT ABOUT CLOGGING?

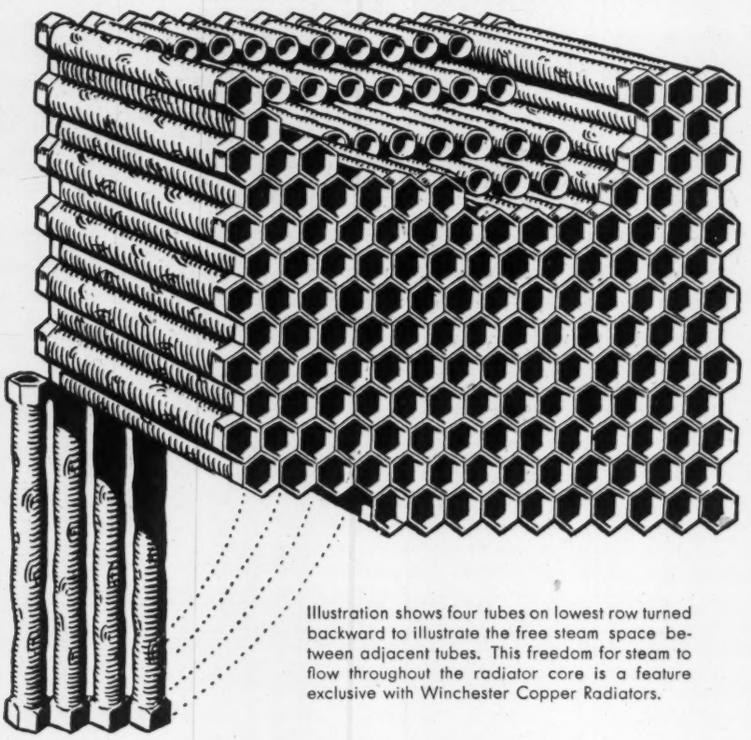


Illustration shows four tubes on lowest row turned backward to illustrate the free steam space between adjacent tubes. This freedom for steam to flow throughout the radiator core is a feature exclusive with Winchester Copper Radiators.

EVERY engineer knows that scale, rust, pieces of gasket, oil, pipe compound and other dirt gradually work their way through steam pipes and lodge in radiators. How does such detritus affect Winchester Copper Radiators?

Examine the drawing above. Notice that the steam space in a Winchester Copper Radiator is exactly like the water space in a return tubular boiler. Dirt which lodges between the tubes doesn't affect the steam flow, virtually does not reduce the radiating surface, actually does not injure it or reduce its efficiency.

You cannot prevent dirt from lodging in radiators but you can render it harmless by using Winchester Copper Radiators in all Unit Heaters.

Ask us for more information

WINCHESTER

TRADE MARK

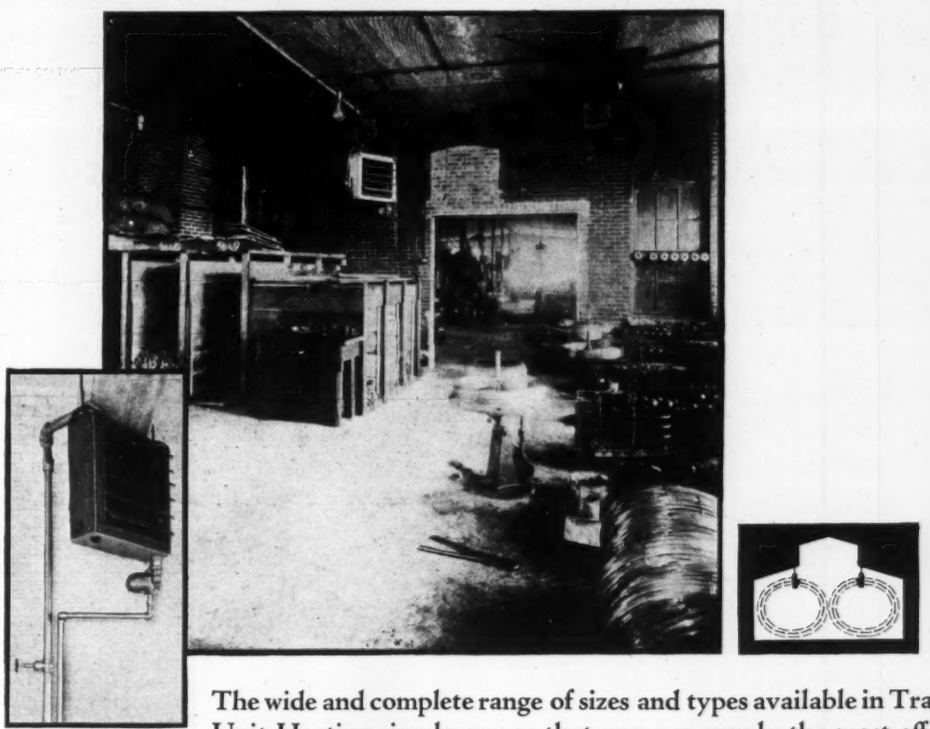
COPPER RADIATORS

RADIATOR SALES DIVISION

WINCHESTER REPEATING ARMS CO.

New Haven, Conn., U. S. A.

CHOOSE FROM 17 TYPES AND SIZES THE MOST ECONOMICAL TRANE UNIT HEATER FOR EVERY JOB



The wide and complete range of sizes and types available in Trane Unit Heating simply means that you can supply the most effective, economical units for the job and avoid either a wasteful or an inadequate installation.

Trane Unit Heaters are sold or specified by more heating contractors and engineers as every day goes by. Why? Because the Trane Unit Heater line is complete. Because Trane ratings are accurate and Trane recommendations are scientifically sound. And because the heater itself is the perfected product of one of the finest engineering staffs in the heating industry.

The patented heating element, foundation of Trane Unit Heating, is constructed for maximum heat transfer with minimum weight. It is made without soldered, brazed or welded joints, with seamless copper tubes rolled into iron headers in typical boiler construction.

First cost of a Trane Unit Heating System is ordinarily 30 to 40% less than cast iron or pipe coil radiation. In addition to this major advantage, Trane Unit Heaters effect continuous economies in operation. They are easily adapted for use in year 'round ventilating systems.

Mail the coupon for free booklet and complete information.

HEAT WITH UNIT HEATERS

TRANE
UNIT HEATING SPECIALISTS

THE TRANE COMPANY, Dept. 12,
212 Cameron Avenue, La Crosse, Wis.

Send free booklet "How to Cut Heating Costs".

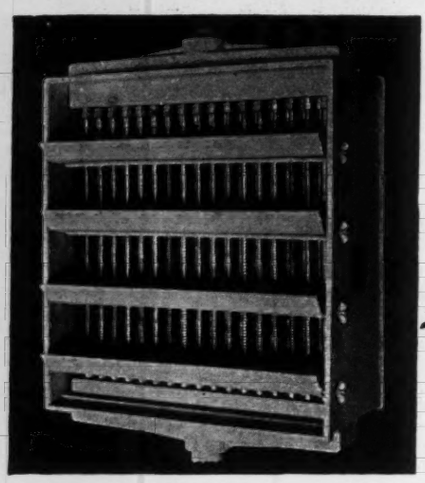
Name.....

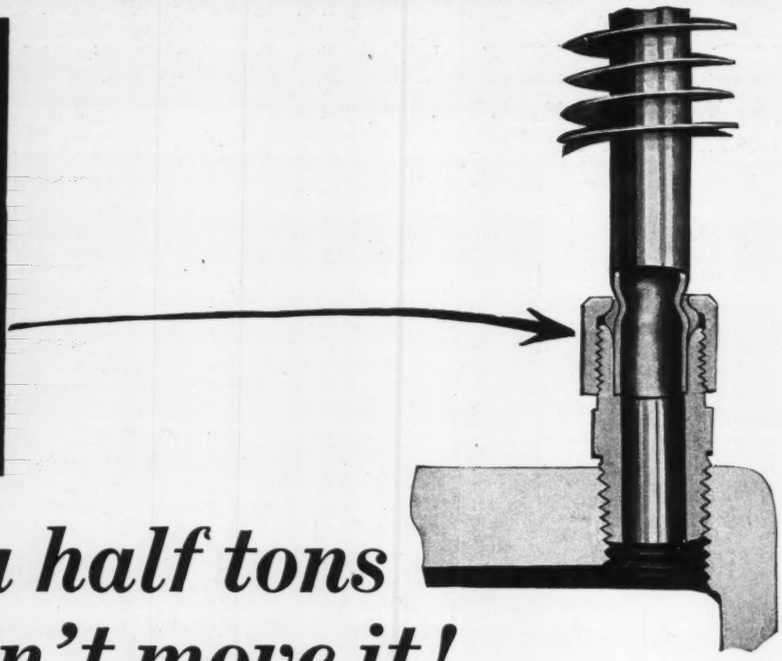
Address.....

City.....

State.....

UNIT HEATERS · DIXIE UNIT HEATERS · DIXIE





Five and a half tons couldn't move it!

There is not much chance today to question the superior heating efficiency and increased effectiveness of heating with Unit Heaters. The question with which you will be more concerned is the quality in their construction and the length of time they will give good heating service.

It is in these particulars that the Dixie Unit Heater is different. Dixie patented compression couplings insure a leakproof connection which under a five and one-half ton pull could not be separated. The Dixie Core will not leak, rust or corrode.

That's Construction! And it's the kind of construction that spells long, trouble free operation.

There's another continuous service feature of the Dixie Unit Heater which will interest you. It is the manner in which the tubes can be easily removed in case of damage without keeping the heater out of service.

	Air Entering Heater	Air Leaving Heater	B.T.U Per Hour	Condensate Per Hour	Equivalent Square feet Direct Radiation	Cubic Feet Air Per Minute	Shipping Weight
No 800 B	40° F	130° F	232620	242 lbs.	960	3200	230 lbs.
	50	136	218250	227	908	3200	230
	60	141	205340	214	856	3200	230
	65	143	200500	208	832	3200	230
	70	144	193510	202	808	3200	230
No. 500	40°	130°	146880	155 lbs.	612	1300	170 lbs.
	50	135	138240	146	576	1300	170
	60	143	128880	136	537	1300	170
	65	145	124800	134	520	1300	170
	70	147	121160	129	509	1300	170
No. 200	40	134°	50880	53 lbs.	212	920	120 lbs.
	50	138	45120	47	188	920	120
	60	142	40320	42	168	920	120
	65	143	38400	40	160	920	120
	70	144	34520	37	148	920	120

Simply remove the damaged tube, plug the opening with a standard size pipe plug and put the heater back in operation:—No trouble, little delay—Continuous Service.

THE DIXIE BLOWER CO.
1351 West 37th Place CHICAGO, ILL.

UNIT HEATERS · DIXIE UNIT HEATERS · DIXIE

To *Insure* YOU 100% *Satisfaction*

Get Into the Habit of Using

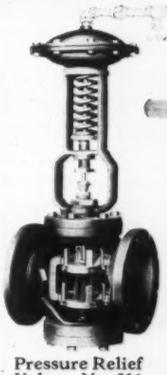
McALEAR'S

Engineering Service

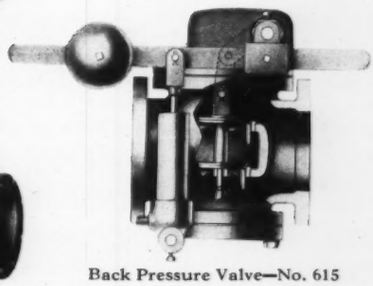
To protect you against any misuse—to assure you the correct equipment for all conditions—to help you solve your pressure and level control problems, McAlear have an engineering service that you are urged to use. These engineers, with over 25 years of field training in the special uses of pressure and level controls, have practical, sound, experience to offer and are fully capable and willing to give their engineering advice on any installation.

This engineering service is maintained solely for your benefit. There are no strings tied to it—no obligations—no charge. Just use it freely.

You should have our new 128 page book with its many pages of typical installations, charts, diagrams, blue prints, etc. Send for it.



Pressure Relief Valve— No. 311



Back Pressure Valve—No. 615

Ball Float Steam Trap—No. 725

The McALEAR MFG. CO.

1909 S. Western Ave. Chicago, Ill.

SALES ENGINEERS IN ALL PRINCIPAL CITIES

McALEAR

Grigsby-Grunow Co. Plants Are Equipped with POWERS Control

PRODUCTION schedules of 6500 radio sets a day require thousands of workers and the Grigsby-Grunow Co. know that they cannot get a full day's work for a full day's pay from employees working in *OVER* or *UNDER*-heated offices and factories.

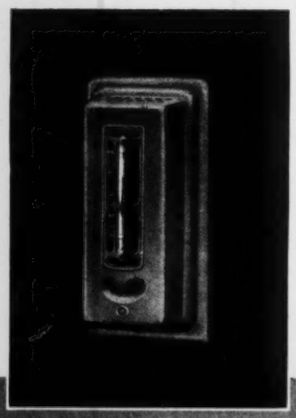
Overheated and underheated factories and offices not only cause a reduction in the output of workers but also lower the quality and accuracy of their work.

The uniform temperature maintained by the Powers System of Automatic Control eliminates these profit leaks. Fewer workers are absent with colds or more serious ills and fuel savings often run from 15 to 50 per cent.

▲ ▲ ▲

The Powers Vapor Disc Thermostat

It costs more. It's worth more! Because it often gives 15 to 20 years of accurate control without repairs of any kind.



THE POWERS REGULATOR CO.

35 Years of Specialization in Temperature Control

Chicago: 2718 Greenview Ave. • *Offices in 35 Other Cities* • New York: 137 East 46th Street

The Canadian Powers Regulator Co., Ltd., Toronto, Ont.

POWERS

Fig. 0402

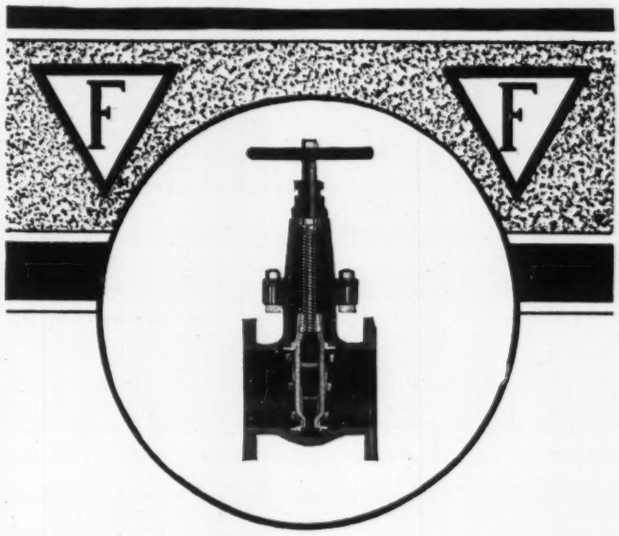


Fig. 0403

Fig. 0404

Fairbanks Standard Iron Body Gate Valves—Screwed and Flanged End—Stationary and Rising Spindle (OS&Y) Types—for 125 pounds Steam Working Pressure and 175 pounds Water Working Pressure.

These valves, as sectional view indicates, are of the solid wedge construction and possess refinements that make for long term valve service.

Valves in these types can be furnished in all iron construction throughout.

Complete Valve Catalog No. 20 sent on application.

Fig. 0405

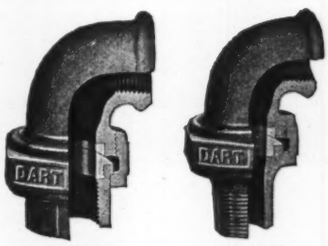


Fig. 0834 Fig. 0835

UNION ELBOWS

DART
Special Unions

Whatever the job there is a DART Special Union that will amply fill the bill. And besides the special designs and types the DART quality is in-built in every one of these unions. They are all equipped with the famous TWO BRONZE SEATS. That is why one DART is equal to two—why they are being used on all the jobs where merit and dependability count most.

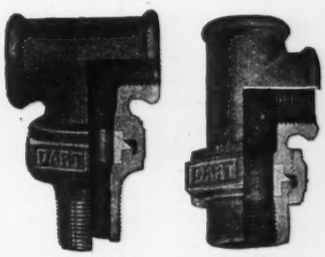


Fig. 0837 Fig. 0838

UNION TEES

Fig. 0840

MALE AND FEMALE UNICN

Fig. 0841

AIR PUMP UNION

THE FAIRBANKS COMPANY

BOSTON NEW YORK PITTSBURGH

Manufacturers of Valves

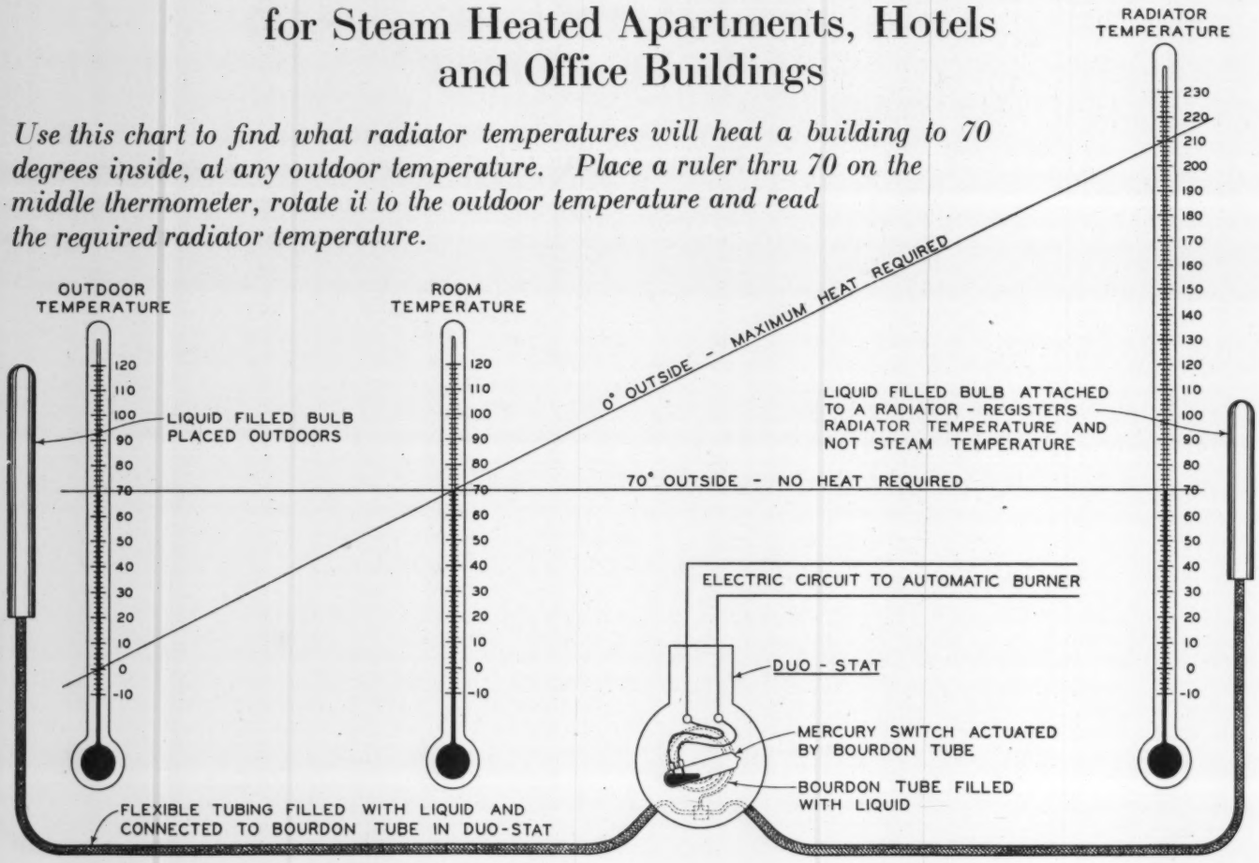
DISTRIBUTORS OF DART UNIONS

A New Method of

SCIENTIFIC HEAT CONTROL

for Steam Heated Apartments, Hotels and Office Buildings

Use this chart to find what radiator temperatures will heat a building to 70 degrees inside, at any outdoor temperature. Place a ruler thru 70 on the middle thermometer, rotate it to the outdoor temperature and read the required radiator temperature.


OUTDOOR TEMPERATURE
ROOM TEMPERATURE
RADIATOR TEMPERATURE
LIQUID FILLED BULB PLACED OUTDOORS
0° OUTSIDE - MAXIMUM HEAT REQUIRED
LIQUID FILLED BULB ATTACHED TO A RADIATOR - REGISTERS RADIATOR TEMPERATURE AND NOT STEAM TEMPERATURE
70° OUTSIDE - NO HEAT REQUIRED
ELECTRIC CIRCUIT TO AUTOMATIC BURNER
DUO - STAT
MERCURY SWITCH ACTUATED BY BOURDON TUBE
BOURDON TUBE FILLED WITH LIQUID
FLEXIBLE TUBING FILLED WITH LIQUID AND CONNECTED TO BOURDON TUBE IN DUO-STAT

The heating plant in any building, with steam heat, is always designed and proportioned to maintain the building at 70 degrees, inside, when the radiator temperature and the outdoor temperature are maintained in the relation shown in the above chart.

The Raymond Duo-Stat controls any automatic steam heating plant, directly from both the radiator temperature and the outside temperature, so as to maintain this relation. It may be adjusted to suit buildings which differ from this standard.

Not only does the Duo-Stat maintain this relation in the one radiator to which it is attached but the operation of the heating plant, under this control, is such that complete and equal distribution of steam to all radiators is positively assured in all kinds of weather.

Radiators are completely filled with steam in cold weather, and only partially filled with steam in mild weather.

This scientific method of control has been applied to all types of heating plants with the following results.

1. Complete satisfaction to the tenants, due to uniform, even heat, and constantly warm radiators without overheating.
2. Complete satisfaction to the janitor due to satisfactory performance of the heating plant under fully automatic control.
3. Complete satisfaction to the owner due to a 10 to 30 per cent reduction in fuel costs resulting from the ability to heat the building properly without wasting fuel in overheating.
4. Complete satisfaction to the dealer due to lack of complaints and service calls.

The Raymond Duo-Stat for steam is an outstanding development in the field of automatic heat, not only as a control instrument but also as an operating principle. So far as we know it is the only instrument which gives satisfactory automatic control of an oil burner in apartments, hotels and office buildings.

It is sold direct to dealers, by us or through our distributors, at a list price of $100. Installation costs vary from $25 to $150, depending upon the installation. It can easily be installed, without special tools, from the instructions which are furnished with the instrument.

A large size copy of the above chart will be mailed you, with complete description of the Duo-Stat, and dealers discounts upon request, mentioning this advertisement.

F. I. RAYMOND CO. Builders Building 228 No. La Salle St. **CHICAGO**

Parks' Parables

Human nature is just as much a study as it ever was. Did you ever notice the attitude of the average buyer; we are all average buyers—you and I—so we can include ourselves.

Did you ever notice the attitude of the average buyer to assume the bidder with the low price has the right price? All the others are crooks in proportion as the price increases.

In certain building operations, the buyer may not realize that the low price may come from a bidder whose crooked intentions were as much reflected in his price as honest intentions were reflected in some of the others.

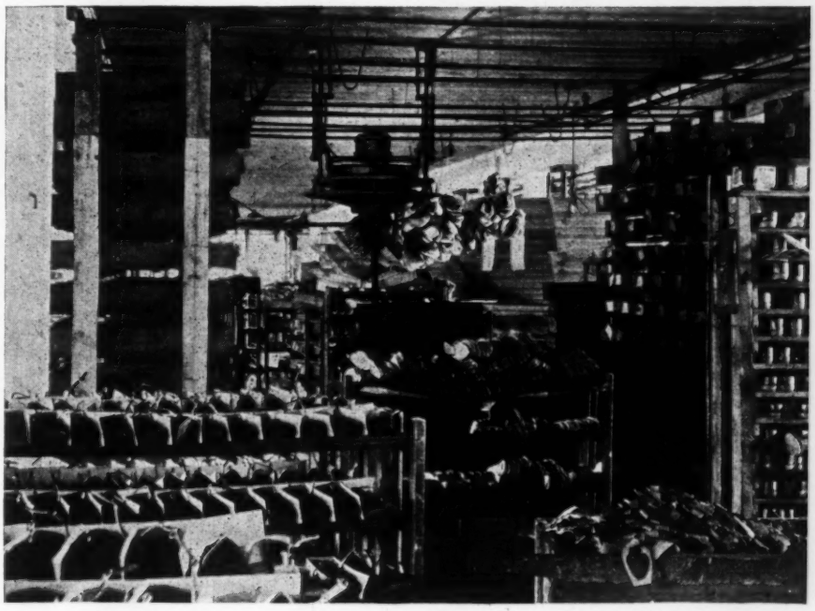
There are two things no buyer has any moral right to encourage: unintelligence or dishonesty. Many low prices are the result of one or the other. Engineers know this; know that their plans and specifications are no better than the contractor who does the work. If low prices are the result of better ability, then the reward is as certain as it is deserved. If they are the result of unintelligence or with an intent to skin, the penalty usually falls on the buyer.

For the amount of the contract involved, the engineer puts more time into industrial piping plans and specifications than in any other part of your project. In other words, his costs of producing these plans and specifications are higher than—let us say—the building plans. Engineers have told me this. It is for this reason we oftentimes do industrial piping engineering ourselves, with no offence to industrial engineers.

But we know when we accept an industrial piping job on an engineer's plan, two reputations are at stake; his own and our own. And even if our own reputations aren't to be considered—and I have a feeling they ought to be after 36 years of effort—the engineer can and has a right to be sensitive about his.

"Parko"

Regulated Humidity *helps solve many Shoe Manufacturing Problems*



ParkSpray Humidification Systems *designed for*

Cigar and Tobacco Plants
Photographic Film Mfgrs.
Printing and Lithographing
Rubber Goods Mfgrs.
Perishable Food Storage
Asbestos Products Mfgrs.
Insulated Cable Mfgrs.
Flour Mills
Explosive Mfgrs.
Textile Mills
Paper Mills
Clothing Makers
Shoe and Leather Mfgrs.
Leather and Rubber Cement
Glassine Paper
Cereal Manufacturing
Varnish
Piano Factories
Testing Material Labs.
Artificial Leather Plants
Households & Auditoriums
Rattan Weaving
Celluloid Manufacture

LEATHER is naturally absorbent. Moisture absorbed hygroscopically greatly improves its pliability. Certain parts of the modern shoe can be conditioned in a pail of water . . . others must be treated in a moist atmosphere. Different methods of shoe-making require different treatments of the leather.

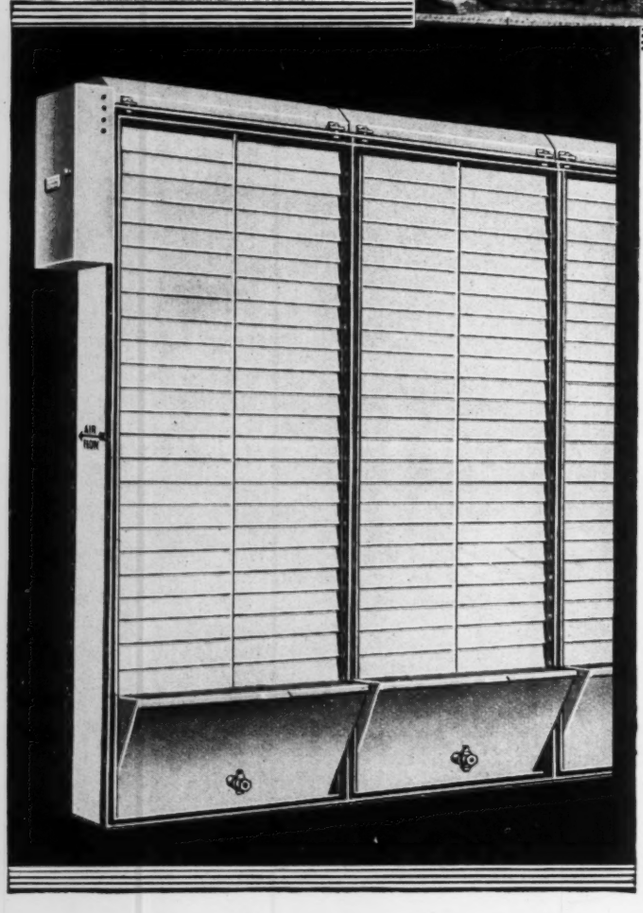
ParkSpray humidifiers are here shown conditioning the soles and uppers of shoes preparatory to lasting. They are paying their keep by producing a better quality with fewer seconds . . . from less raw material; an expensive raw material, too.

A portfolio of installations in various industries is interesting reading. Send for a copy.

ParkSpray Humidification Systems

Parks-Cramer Company 977 Main St., Fitchburg, Massachusetts

IN *the* CAPITOL



REED FILTERED AIR is an essential part of the air conditioning in both the House and Senate. "Manufactured weather" installed by the Carrier Engineering Corporation now makes "every day a perfect day" by controlling temperature, humidity, air distribution and air cleanliness. Reed Air Filters were selected for their high efficiency in dust removal, low operating resistance and dependabe service. "Reed Air is clean air—guaranteed 97% free from dust, soot and bacteria."

Bulletin No. 117 contains the story of the development of "Panel" principle of automatic air-cleaning—the most phenomenally successful method yet devised—a copy is yours for the asking—no obligation.

Reed Air Filters

Licensed under American Air Filter Patents

REED AIR FILTER COMPANY
INCORPORATED
207 Central Avenue, Louisville, Kentucky

The Medical Center Group
James Gamble Rogers, Inc.
Architects . . . New York

Equipped With Johnson Heat & Humidity Control . . . .
Grant . . . . . *Photo.*

THE wide preference awarded Johnson Heat and Humidity Control evidences a valued utility and a leadership. Every type of building, in every state of the Union, contains Johnson Control. The prominence of these structures and the prominence of the architects and engineers responsible for them and recommending Johnson Control are additionally significant.

Johnson Heat & Humidity Control is fundamentally correct in design and installation: and totally reliable mechanically and in constancy of service. That is why Johnson Control is so universally specified.

The Johnson System consists of individual room thermostat and diaphragm operated valve or damper for each room to be controlled; and a compressed air system — all completely connected by small, concealed compressed air piping. Included, are thermostats for controlling the valves and dampers of a building's ventilating system, and humidostats for the control of the humidity. Johnson Control applies to every form and plan and system of heating and ventilating. Interesting Johnson Book of details sent on request.

JOHNSON SERVICE CO. MILWAUKEE, WIS.
Established 1885
Branches In All Principal Cities

JOHNSON
HEAT & HUMIDITY CONTROL

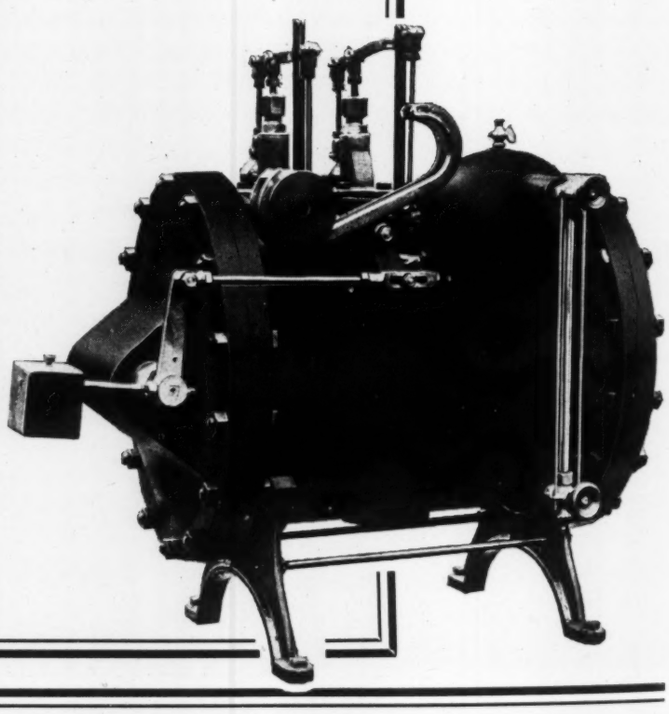
The All Metal System . . . . The All Perfect Graduated Control of Valves and Dampers.

The Dual Thermostat (Night and Day) Control . . . . Fuel Saving 25 to 40 Per Cent.

why STERLING SYSTEMS are Supreme

Sterling Systems for draining UNIT HEATERS, DRYING MACHINES, BLAST COILS AND STORAGE HEATERS are supreme because of their simple operation, long life, increased efficiency and trouble-free service. They will give excellent results either for returning high or low pressure condensate direct to boilers at high temperatures at about 300° F. or more or as direct lift pumps. We will be glad to furnish typical installation layouts, specifications and details of mechanical construction upon request.

Branch offices in principal cities



STERLING ENGINEERING & MFG. CORP.

(TEMPLETON MFG. CO.)

117 BUSINESS STREET, HYDE PARK BOSTON, MASSACHUSETTS

Showing installation of Reading Charcoal Iron Boiler Tubes (Scotch Marine Type) in the boilers of the Southern Pacific Steamship Company's *S. S. El Occidente*

TO know the truth about boiler tubes, look into their past—the record of known savings effected through their use. With Reading Charcoal Iron Boiler Tubes, you will find this record stretching back for generations—countless installations in every class of service where Reading Charcoal Iron Boiler Tubes have meant greater economy! What better proof could there be that Reading Tubes will save money for you, too?

The inherent structure of Genuine Charcoal Iron resists corrosion and metal "fatigue". That is why Reading Tubes last several times longer than ordinary tubes. The stencilled name "Reading" guarantees that you get Genuine Charcoal Iron.

READING IRON COMPANY, Reading, Pennsylvania

Atlanta · Baltimore · Cleveland · New York · Philadelphia · Boston
Cincinnati · St. Louis · Chicago · New Orleans · Buffalo
Houston · Tulsa · Seattle · San Francisco · Detroit
Pittsburgh · Ft. Worth · Los Angeles · Kansas City

Reading Charcoal Iron Boiler Tubes are furnished in sizes ranging from 1½" to 6" in diameter and may be obtained through the following distributors:

John McKenzie and Co.
Baltimore, Maryland

Williams and Co.
Cincinnati, Ohio

Williams and Co.
Cleveland, Ohio

Harrisburg Pipe & Pipe Bending Co.
Houston, Texas

Standard Supply & Hardware Co.
New Orleans, La.

John B. Astell and Co.
New York, N. Y.

Eagleston Parke, Inc.
Norfolk, Va.

John B. Astell and Co.
Philadelphia, Pa.

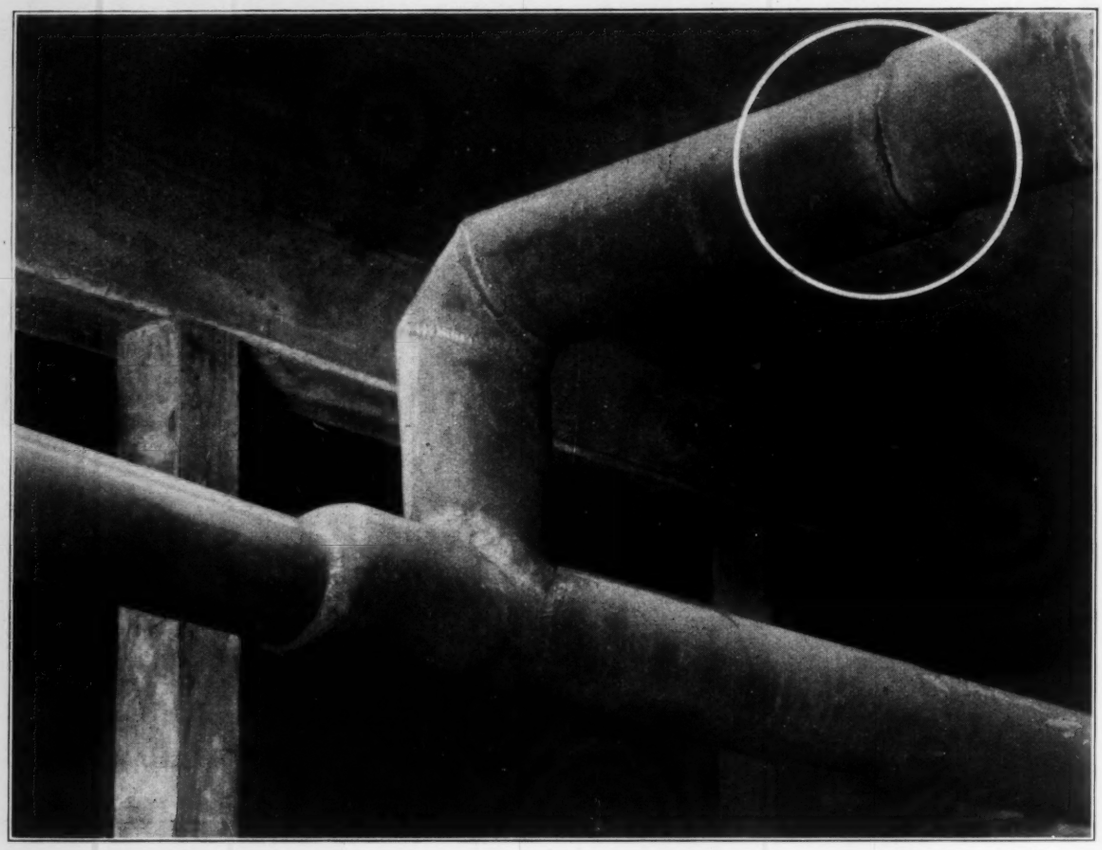
Williams and Co.
Pittsburgh, Pa.

A. M. Castle & Co.
Chicago
Seattle
San Francisco
and
Los Angeles

Pidgeon-Thomas Iron Company
Memphis, Tenn.

Export Agents,
Wonham, Inc.
New York City

READING PIPE
CHARCOAL IRON BOILER TUBES



WELDED PIPING IN THE WORLD'S TALLEST BUILDING

An eccentric reducer, a T connection, a mitered 90° joint are shown here completely fabricated by oxyacetylene welding and cutting, and in the circle, work is started on oxyacetylene cutting out a piece of pipe where flanges for inserting a valve are to be welded in.

This is just one of the hundreds of places in the extensive piping requirements of the Chrysler Building, New York City, where Airco Oxygen, Acetylene and Airco-Davis-Bournonville Welding and Cutting Apparatus have proved the best solution to the installation problem.

AIR REDUCTION SALES COMPANY

HOME OFFICE: 342 MADISON AVE., NEW YORK

Baltimore	Buffalo	Dayton		Louisville	Philadelphia	Seattle
Bettendorf, Ia.	Charlotte, N. C.	Detroit		Milwaukee	Pittsburgh	St. Louis
Birmingham	Chicago	Emeryville, Cal.		Minneapolis	Portland, Ore.	Wheeling
Boston	Cleveland	Jersey City		New Orleans	Richmond	90 Plants
		Los Angeles		Oklahoma City		

AIRCO — DAVIS BOURNONVILLE

Airco Oxygen — Airco Acetylene — Airco-Davis-Bournonville Welding and Cutting Apparatus — Supplies — Airco National Carbide

Pump rating *merely* in sq. ft.
may prove a boomerang . . .

To Insure Heating Pump Performance

tested air and water capacities should substantiate published ratings

CONDENSATE to be removed from a return line vacuum heating system may vary in volume as much as 40%. Quantity of air or vapor also fluctuates widely. For this reason, square feet of installed radiation is not the only factor to consider in choosing the correct size of pump to use. Several others must be recognized. Pressure in the system, efficiency of traps, tightness of joints, fittings and valves cannot be overlooked.

So, every Jennings Vacuum Heating Pump is rated by guaranteed air and water capacity determined by actual test. For a specified amount of radiation, a given size of Jennings Pump is recommended only if its combined air and water capacity is proved adequate to handle this radiation under all conditions. A Jennings Pump with the air and water capacities given in the table can be relied on to serve satisfactorily any reasonably well installed system for the life of the building.

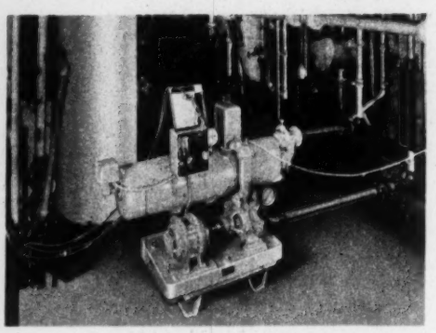
Actual Tests Determine Jennings Pump Capacity

Air and water capacities are accurately measured. The pump is tested with its own motor and control equipment. The entire assembly is made to prove its fitness for the work which it has to perform. A certified report of the test is furnished to the purchaser.

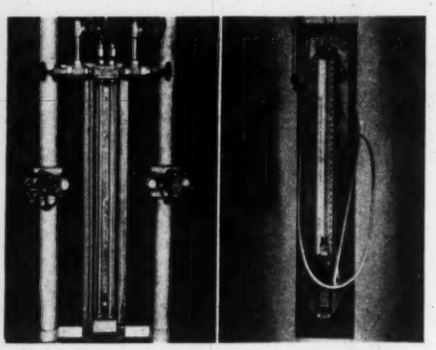
CAPACITIES OF JENNINGS VACUUM HEATING PUMPS

Pump Size	Equivalent Direct Radiation Square Feet	Water Capacity G.P.M.	Air Capacity Cu. Ft. Per Min.	Orifice Diameter Inches	MOTOR HORSEPOWER			
					10 Lbs.	20 Lbs.	30 Lbs.	40 Lbs.
T	2,500	4	3	1/64	1/3	1/2	1	1 1/2
U	5,000	9	3	1/64	1/3	1/2	1	1 1/2
V	10,000	14	6	3/64	1	1	1 1/2	2
B	16,000	22	9	3/64	1 1/2	2	3	5
C	26,000	35	15	1/4	2	3	5	5
D	40,000	60	19	5/64	3	5	5	7 1/2
E	65,000	90	34	3/8	5	5	7 1/2	10
F	100,000	140	50	7/16	7 1/2	10	15	15
*G	150,000	200	102	5/16 & 3/8	10	15	UPON REQUEST	
*H	300,000	400	171	2-3/16 & 1-3/8	UPON REQUEST			

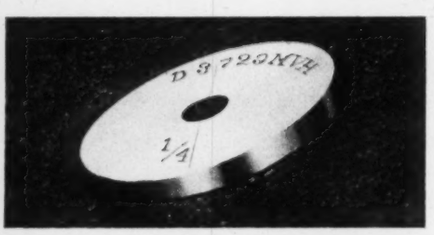
* *The last two sizes are not of the manifold type.*



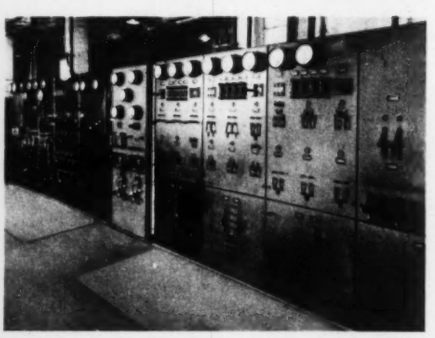
JENNINGS VACUUM HEATING PUMP ON TEST STAND



TYPE OF VENTURI METER AND VACUUM MANOMETER USED IN TESTING JENNINGS VACUUM HEATING PUMPS



STANDARD TEST ORIFICE



SWITCHBOARD IN NASH TEST PLANT WHICH FURNISHES ELECTRIC CURRENT OF ANY VOLTAGE, PHASE AND FREQUENCY

Water Capacity Is Tested by Venturi Meter

Water capacity is checked by testing the volume of water in g.p.m. that the pump removes from the receiving tank *under the given vacuum* and delivers against the specified discharge pressure.

Air Capacity Is Measured by Calibrated Orifice

Air capacity is found by means of a calibrated orifice of specified diameter, reamed in a brass plate one-eighth inch thick, located in the pump suction, and communicating with the receiving tank. This orifice determines the cubic feet per minute of air that the pump withdraws from the receiving tank and discharges to the atmosphere.

Air capacity is determined at the same time that the pump is delivering its rated volume of water. Water capacity is measured while the pump is handling its maximum rated quantity of air.

Only by such *tested* air and water capacities can good heating pump performance be assured. It pays to demand a certified factory test report, and to substantiate this wherever possible by a second test on the job.

CERTIFIED REPORT OF TEST

Jennings Pumps

NASH ENGINEERING CO.
SOUTH NORWALK, CONN., U. S. A.

Carrier Centrifugal Refrigeration Unit used in conjunction with Carrier Systems of air conditioning in rayon plants.

HELPING MAN *beat the silkworm*

Manufactured Weather is vitally important to the delicate processes of rayon production

THE silkworm eats mulberry leaves—and the cellulose they contain becomes silk fiber. Man extracts raw cellulose from plants—and by chemistry produces filaments of lustrous rayon.

Think how exact must be this delicate chemical process . . . how perfectly manufacturing conditions must be maintained in order to duplicate Nature, and change a liquid into millions of pounds of shimmering thread!

For one thing, temperature and humidity must be controlled absolutely—day and night, winter and summer. And here *Manufactured Weather*, the Carrier name for Scientific Air Conditioning, plays an always essential part.

This System *automatically* cleanses the air of impurities before delivering it indoors, *automatically* regulates the temperature and humidity of this air, and *automatically* controls its movement.

But *Manufactured Weather* serves other industries besides rayon. More than two hundred of them are using it to advantage and profit—amazing profits, in some cases.

And this System is also a source of health and comfort to people. Its advantages are enjoyed by both Houses of Congress, the employees and customers of large department stores, the patrons of many restaurants and theatres. And the owners of many large office buildings, too, are coming to realize the value of *Manufactured Weather*.

There are many new and intricate problems of air conditioning that are constantly presenting themselves in building construction. To solve these problems, whatever they may be, Willis H. Carrier and his Associates are always glad to cooperate with the consulting engineer, the architect, the builder and the owner.

MANUFACTURERS AND FABRICATORS OF RAYON WHO USE CARRIER SYSTEMS

The Viscose Company
Lewistown, Pa.

The Viscose Company
Marcus Hook, Pa.

The Viscose Company
Meadville, Pa.

The Viscose Company
Roanoke, Va.

The Viscose Company
Parkersburg, W. Va.

Celanese Corp. of
America, Amcelle, Md.

American Bemberg Corp.
Elizabethton, Tenn.

American Glanzstoff
Corp., Elizabethton,
Tenn.

Tubize Artificial Silk
Co., Hopewell, Va.

American Chatillon
Corp., Rome, Ga.

American Enka Corp.
Asheville, N. C.

New Bedford Rayon Co.
New Bedford, Mass.

Delaware Rayon Corp.
New Castle, Del.

Du Pont Rayon Co.
Buffalo, N. Y.

Du Pont Rayon Co.
Richmond, Va.
Old Hickory, Tenn.
(Carrier Centrifugal
Refrigeration)

Fiberloid Corp.
Indian Orchard, Mass.

Skenandoa Rayon
Corp., Utica, N. Y.

Industrial Rayon Corp
Cleveland, Ohio
Covington, Ky.

Woonsocket Rayon Corp.
Woonsocket, R. I.

Belamose Corp.
Rocky Hill, Conn.

Aberfoyle Mfg. Co.
Fabricators of rayon
and rayon mixtures
Chester, Pa.

Carrier Engineering Corporation

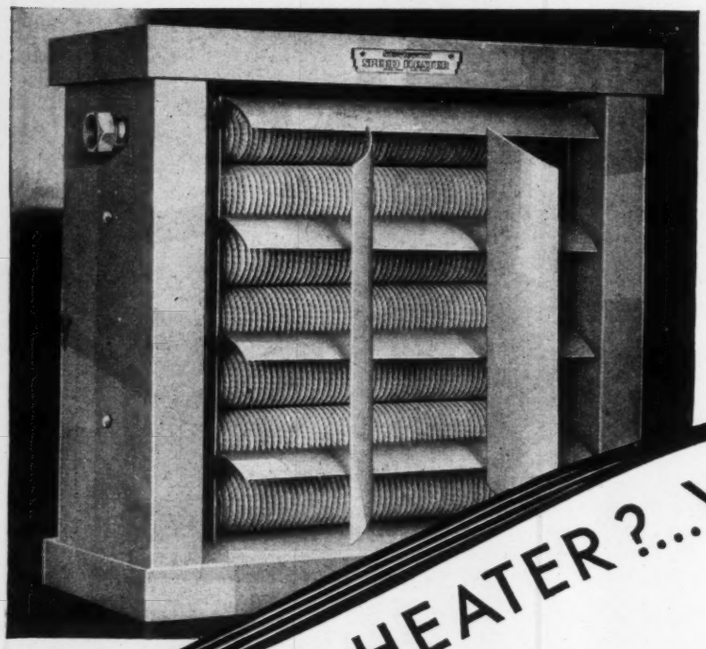
NEWARK, NEW JERSEY

CARRIER ENGINEERING CO., LTD.
LONDON, PARIS, BOMBAY
CALCUTTA, JOHANNESBURG

OFFICES: New York, Philadelphia, Boston, Chicago, Cleveland, Washington, Detroit, Kansas City, Dallas, Los Angeles

CARRIER LUFTTECHNISCHE GESELLSCHAFT
STUTTGART, BERLIN

Manufactured Weather *makes* "Every day a *good* day"



AN IMPROVED HEATER?...Yes, Sir!

HIGH PRICED?...no, sir!
FAST SHIPMENT?...48 hours
WELL MADE?...Sturtevant!

YOU have the whole story in the headline...almost! This is the smallest heater Sturtevant ever designed... but they were designed for a big, active market. Garages, auditoriums, factories, workshops, theatres, greenhouses, hangars, stores, auxiliary or booster heating, drying...applications are legion!

When it comes to operation...we rest on our reputation! ...We have one...some sixty years old!

And about price...SPEED HEATERS can be specified and contractors will be delighted to bid! Prices hit a new low!

We'd like to send you all the data you need...either a catalog or specific personal information. One of our representatives will be glad to call—on request.

The coupon awaits your pencil!

THE PRICE IS 'WAY DOWN

COUPON

B. F. STURTEVANT CO.
Hyde Park, Boston, Mass.

Kindly send me a copy of the SPEED HEATER DATA BOOK.

Name of Company.....

Street Address.....

City.....*State*.....

B. F. STURTEVANT COMPANY

Plants and Offices at: Berkeley, Cal. ◥ Camden, N. J. ◥ Framingham, Mass. Galt, Ontario ◥ Hyde Park, Mass. ◥ Sturtevant, Wis.

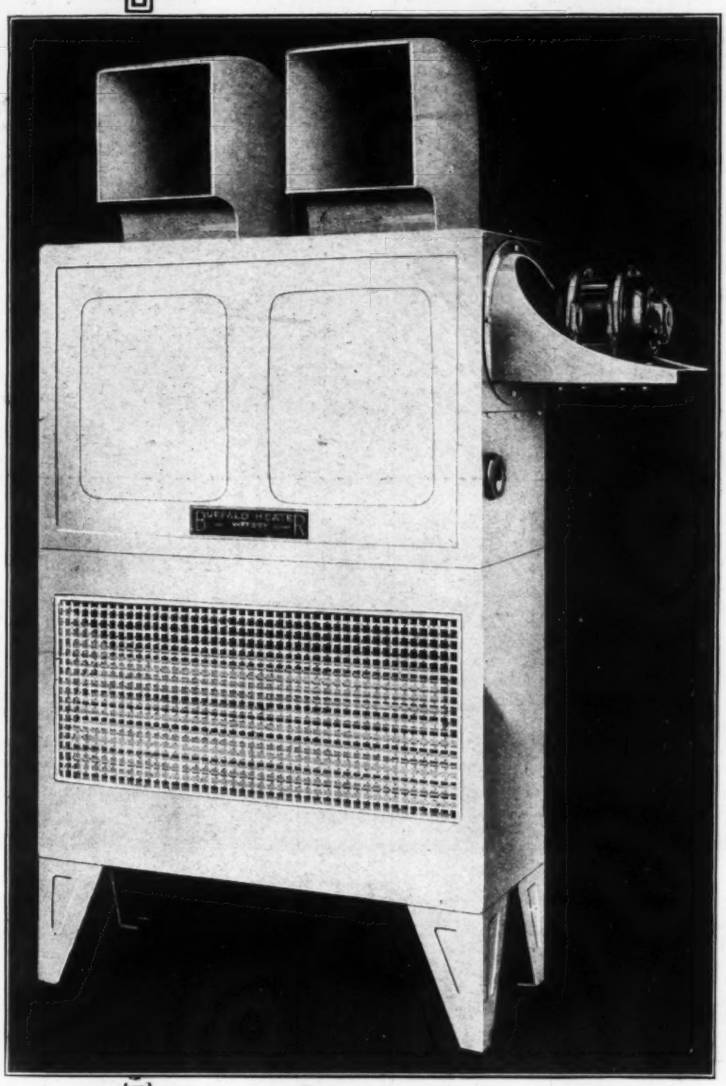
Branch Offices at: Atlanta; Boston; Buffalo; Camden; Charlotte; Chicago; Cincinnati; Cleveland; Dallas; Denver; Detroit; Hartford; Indianapolis; Kansas City; Los Angeles; Milwaukee; Minneapolis; Newark; New York; Omaha; Pittsburgh; Portland; Rochester; St. Louis; San Francisco; Seattle; Washington, D.C. *Canadian Offices at:* Toronto; Montreal and Galt. ◥ *Canadian Representative:* Kipp Kelly, Ltd., Winnipeg

Also Agents in Principal Foreign Countries

Sturtevant
(REG. U. S. PAT. OFF.)

SPEED HEATERS
"More Heat Less Steam"

This is the new



"Buffalo"

Wetboy

A unit heater that washes, heats and humidifies air

Since the advent of the unit heater there has been a real need for a unit that would wash and humidify — at a moderate price!

The Buffalo Wetboy offers you an ideal heater with the cleaning efficiency of a scrubber washer.

The Wetboy is simple—no pump — no outside mechanism, self contained, and easily cleaned.

Get the whole story!

PATENTS APPLIED FOR

UNIVERSAL AEROFIN

Of course, the heating coil used is non-corrosive light-weight Universal Aerofin.

Buffalo Forge Company
171 MORTIMER BUFFALO, N. Y.
In Canada: Canadian Blower & Forge Co., Ltd., Kitchener, Ont.

"Buffalo" *and* **Highboy, Lowboy and Wetboy Unit Heaters**

at Sanitary Felt Products Co.

TWENTY American-Marsh Centrifugal Pumps and two American-Marsh Duplex Reciprocating Pumps are now operating in the new plant of the Sanitary Felt Products Co., Richmond, Va., subsidiary of Simmons Co.

At left above is shown a 10-inch Turbine Driven Centrifugal Pump which delivers water to the 300,000-gallon settling tank.

At right above is shown two of the six Motor Driven Centrifugal Pumps used for handling caustic soda bleach and liquid chlorine.

All pumps are involved in operations that demand unfailing performance. Pump shut-down at Sanitary Felt Products can mean a heavy loss to production.

Wherever a great deal depends upon the pumping equipment, American-Marsh deserves serious consideration. Here is equipment which embodies the highest type of engineering skill together with sound, heavy-duty construction. Proven by over 200,000 satisfactory installations.

Many executives and engineers find it profitable to consult American-Marsh first. Write us for any information required.

NEW DEVELOPMENT

Send for Bulletin 61 giving full details on our new Super Efficient Ball Bearing Pumps—an outstanding advancement.

American Steam Pump Co.
BATTLE CREEK, MICH.
Sales Engineering Offices in Principal Cities

Complete Line of Centrifugal, Steam and Power-Driven Pumps

AMERICAN-MARSH PUMPING EQUIPMENT

Large and Small Pumps for every Industrial Application

The costliest thing on earth?

DIAMONDS, platinum, radium—the world's supply is worth but a fraction of the annual cost of human illness and human inefficiency.

Industry's heaviest toll is the loss produced by lost workers, lost time, lost productivity due to lack of adequate heating, ventilating, air-conditioning in homes and work places.

What is Industry doing about it? If you want to know, come to Philadelphia January 27 to 31—Visit the International Heating and Ventilating Exposition. See what science has produced for heating, ventilating, air-conditioning. See today's means, machinery, materials, apparatus, instruments, equipment. Examine them at your leisure. Compare—Discuss them with the specialists in attendance for that very purpose. See the many ways in which you can reduce the high cost you yourself pay for human disability. You ca cut your contribution to this expense. Cc me and see how. Note the date on your engagement pad!

International Heating & Ventilating Exposition

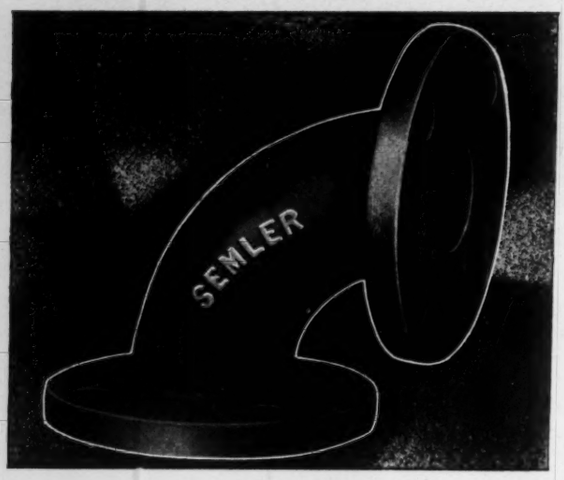
Under Auspices American Society Heating & Ventilating Engineers

International HEATING & VENTILATING EXPOSITION Commercial Museum PHILADELPHIA

Commercial Museum, Philadelphia
January 27 to 31, 1930

3716

Management International Exposition Co., largest industrial exposition organization in the world.



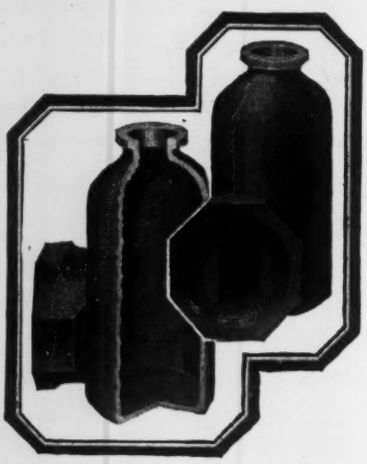
• SEMLER SURE-FIT •

FLANGED FITTINGS

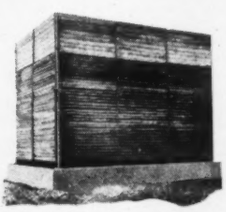
Standard in every respect, fully meeting every requirement and made to give enduring service unfailingly, Semler SURE-FIT Flanged Fittings are made for the trade who appreciate good fittings. After a job is done it's too late to regret delays and costly repairs—make sure of the quality of the fitting first—insist on Semler SURE-FIT.

SURE-FIT FITTINGS SEMLER STEAM FLANGED SPRINKLER DRAINAGE

SEMLER COMPANY
JEANNETTE-PA.
SURE FIT FITTINGS

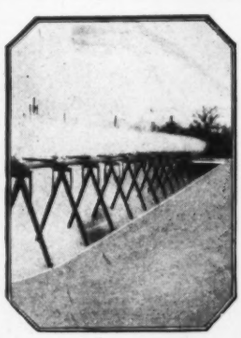


MARLEY
OFFERS A
COMPLETE LINE
OF
SPRAY COOLING
EQUIPMENT



—SPRAY NOZZLES
—SPRAY PONDS
—COOLING TOWERS

Send Us Your Inquiries and ask for Catalog



THE MARLEY CO.
1737 Walnut St.
KANSAS CITY, MO.

To owners and prospective owners of air conditioning Systems==

OWNERS of air conditioning systems manufactured by the Bentz Engineering Corporation of Newark, New Jersey, will be interested to know that this corporation has been purchased in its entirety. The satisfactory performance and dependability of equipment already installed is of necessity, a part of our responsibility in this purchase. Our engineers will be glad to answer promptly all questions pertaining to the proper operation of your equipment.

To engineers and executives in all lines of industry, interested in the application of air conditioning to their own manufacturing processes, we offer the services of an organization ably managed, securely financed, with adequate production facilities and a capable engineering staff== ample assurance of our ability to execute contracts of any size.

MARYLAND AIR CONDITIONING CORPORATION

Clarkson, McComas, Donaldson and Race Sts.

Baltimore, Maryland

Since Vilter 1867

Complete Plants for Air Conditioning

IN the theatre or auditorium particularly, air conditioning involves not only a design to fulfill physical requirements, but operating costs as well. The latter item must be inside the financial limit justified by the revenue of the house. ¶Since 1867 Vilter precision machinery has been standard. From 1882 to now, Vilter-made refrigeration machinery has been a byword. ¶Whatever your problems may be, so long as they are concerned with any phase of refrigeration, Vilter engineers are ready and willing to serve you. ¶Simply write our Engineering Department... full data will be sent you regarding the most modern developments in this highly specialized field.

The Vilter Mfg. Co.
899 Clinton Street
Milwaukee, Wis.

7-29

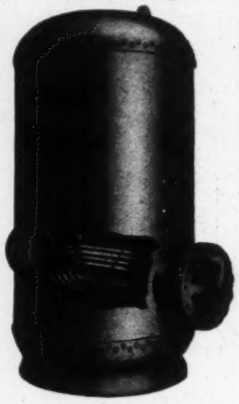
THE VILTER MFG. CO.
899 Clinton St., Milwaukee, Wis.

Please send me data on Air Conditioning ( ) Water Cooling ( )

Name.....

Address.....

GERSTEIN & COOPER
Copper Storage Tanks



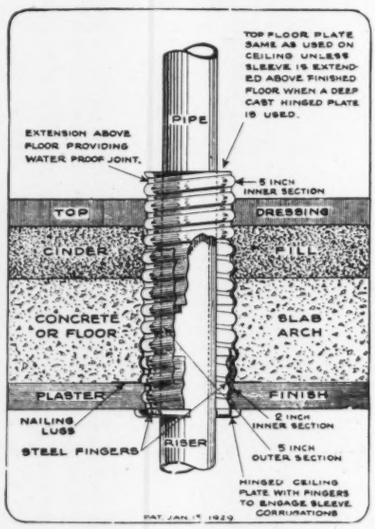
VERTICAL TYPE

THIS tank, made of the finest of Lake Copper, will be found exceedingly adaptable for use on hot water process hook-ups. It is furnished either with or without heating element and is riveted to specifications. *Write for full details.*

GERSTEIN & COOPER COMPANY
1 W. Third Street - So. Boston, Mass.
New York Office: 166 West 72nd Street, N.Y. C.
G. MASON PRICE, 832 St. James Street, Montreal, Quebec, Canada

You Adjust It as the Job Progresses

Extensible PIPE SLEEVE



Saves Labor
Saves Time

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Cleaner
Stronger

SUPER SLEEVE
Pat. Jan. 15, 1929

Adjustable for each stage of construction.

Does away with clipping, after-patching and messy work.

The only standard galvanized pipe sleeve of its kind. Write for special bulletin.

SUITABLE FOR ALL TYPES OF BUILDINGS AND SIZES OF PIPES. ALSO RADIATOR CONNECTIONS

Knowles Pipe Sleeve Company
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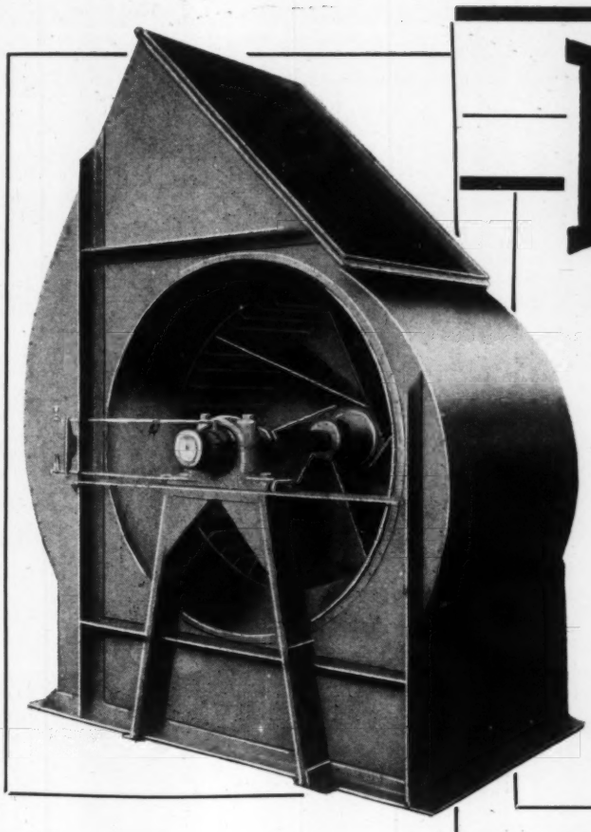

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MULTIBLADE FANS *and* BLOWERS

Lehigh Fan & Blower Co.

Allentown, Pa.

SPECIFY QUALITY

"We Keep Others in Hot Water"

Supplement your mechanical specifications with a requirement for quality and then see that Sims Storage Type Water Heaters—Sims Water Tube Heaters or Converters are used.

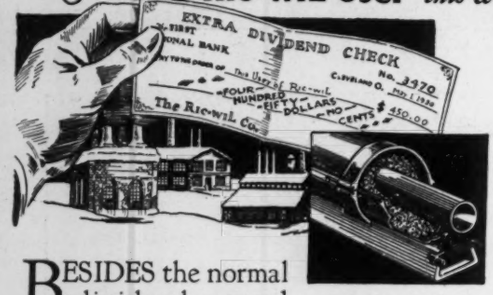
Furnished with either "U" or straight tubes.

The Sims Company, P. O. Box 700, Erie, Pa.

SIMS

Storage Type Water Heaters—Converters

A $450.00 EXTRA DIVIDEND For One Ric-wiL User this Winter



BESIDES the normal dividend a good central heating system pays out of profits that come from lower coal and labor bills, reduced fixed charges and other economies, owners of steam distribution lines in Ric-wiL Conduit will receive an extra dividend this winter.

Note how fully engineered Ric-wiL Conduit is: the flat-bottom base drain that supports the tile conduit, increasing its strength fully 35%; the independent pipe supports; the Loc-liP side joint that reseals the tile split for easy installation.

It will come to them directly out of the *extra efficiency* of Ric-wiL, efficiency over and above the guaranteed 90%, out of the Ric-wiL ability to hold heat losses from 2% to 5% lower than can be expected from ordinary conduits.

As an indication of what this means, take the case of one customer in New York who has a 2400 foot run of steam line insulated with Dry-paC in Ric-wiL Conduit. On the basis of an actual test of efficiency, the extra over 90% saving to the owner will amount to $450.00 per year.

Test after test of Ric-wiL installations of all kinds, various lengths of runs, different sizes of steam pipes, different ground and weather conditions, are showing this extra-dividend efficiency.

The cause is clear: Ric-wiL is an underground insulating system unusually well drained, strong and watertight, with the extraordinary Dry-paC insulation in closed construction to guarantee its permanent dry efficiency.

By all means, investigate this extra-dividend conduit for your next job.

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1569 Union Trust Building Cleveland, Ohio
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Originators of Waterproof Conduit Fillers
RIC-WIL
UNDERGROUND CONDUIT

CONTROLLED TEMPERATURES MEAN HEATING ECONOMY

UNCONTROLLED heating is wasteful. No manual control can be economical —or healthful—because of the unavoidable wide temperature fluctuations.

The Thermotrol—which regulates room temperatures through regulation of individual radiators — will accomplish fuel economies that are almost unbelievable because it eliminates wasteful heating.

The Thermotrol is simple to install, accurate in its functioning, inexpensive to buy and maintain and it will save ⅓ to ½ of the fuel bill.

It pays for itself out of savings.

Ask us for complete information.

STERLING ENGINEERING CO.
1642 Holton Street Milwaukee, Wis.
Representatives in principal cities

The Thermotrol

Hoffman-Economy Vacuum Pumps

JET TYPE VACUUM PRODUCER

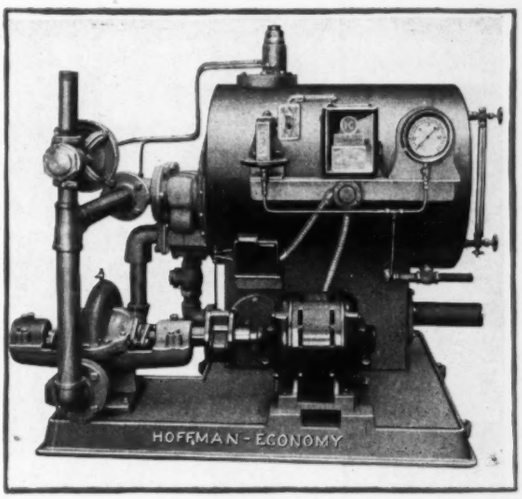
Eliminates Close-Fitting Moving Parts

Hoffman - Economy Vacuum Pumps offer engineers and heating contractors a highly efficient and dependable unit for removing air from the system and returning condensation to the boiler.

The jet type vacuum producer is simple and trouble-proof. It has no close-fitting, moving parts to wear out under normal conditions or cut away and score under abnormal conditions.

The jet type vacuum producer also makes it possible for Hoffman-Economy Pumps to handle hotter water than any other type of vacuum pump —thus eliminating one of the most common causes of unsatisfactory service with such equipment.

Hoffman-Economy Vacuum Pumps are smooth and quiet in operation, are capable of "pulling" a high vacuum and there is no possibility of water over-flowing to floor even in event of electric current failure.

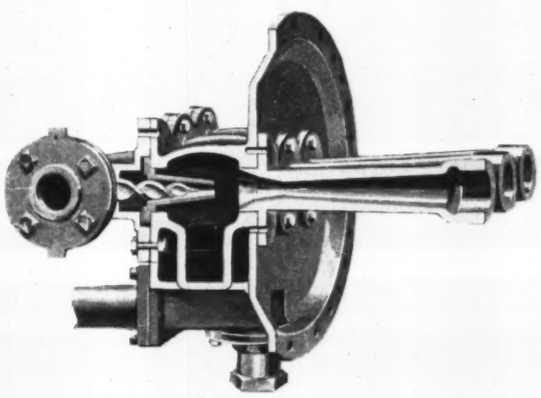


Location of return inlet and float switch close to floor reduces pits and lift fittings to a minimum.

Standard pumps will operate against 20 pounds boiler pressure.

Hoffman - Economy Pumps are also made in other types: Horizontal Condensation Pumps, Reciprocating Pumps, Vertical Underground Pumps and Air Line Vacuum Pumps.

All units are sturdily constructed, mounted on heavy cast iron base and equipped with motors of standard make and size. Write for catalogue and complete information.



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HOFFMAN MOTO-HEATERS

Hoffman Moto-Heaters are an improved type of unit heater that provide maximum efficiency at lowest cost per B. T. U., and are guaranteed for any operating pressure up to 200 pounds. Furnished with Super-Fin heating surface and made in both suspended and floor mounted styles, in a complete range of sizes. Write for catalogue.

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Hoffman Specialty Company, Inc.
Dept. FG-8, Waterbury, Conn.

Please send catalogue on:

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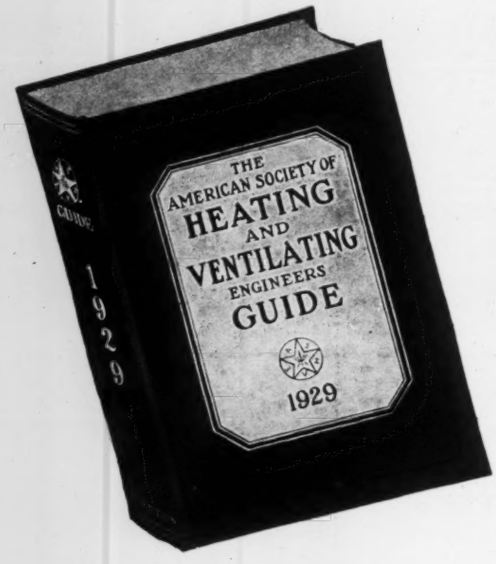
.....Hoffman Moto-Heaters

Name.....

Street.....

City.....State.....

By.....



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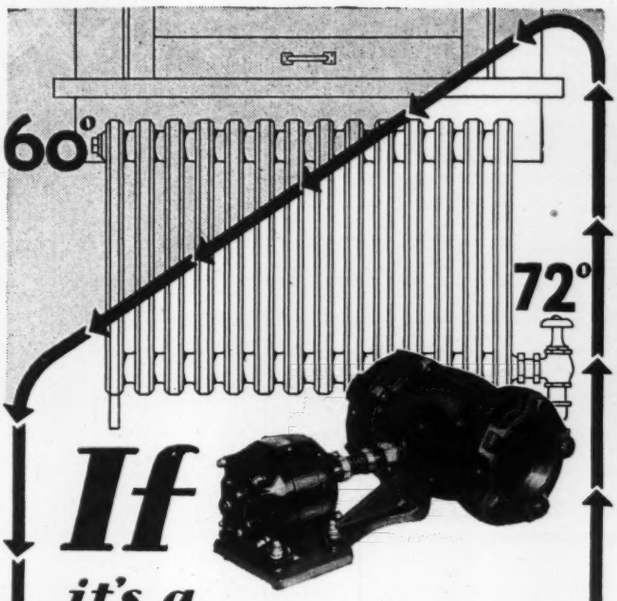

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It saves fuel
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A simple, quiet, unit—inserted in the return line. That's all. Easy to install, easily controlled and as long lived as your boiler.

Ask us about it.

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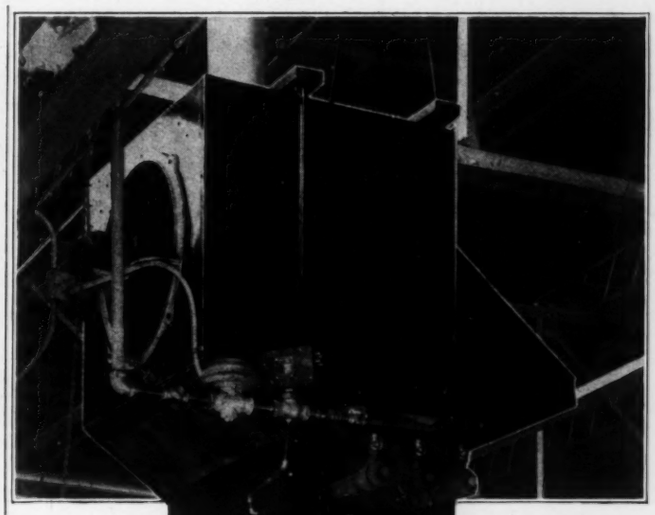

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Here's how!

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With "SUNNYAIRE" in your plant, you can eliminate boilers, boiler rooms, stacks, coal and coal storage, stokers, radiators, piping, pipe covering, boiler inspection, boiler cleaning, grit, dirt, smoke and soot, water bills and licensed fireman.

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Hot Air when You want It!

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Originators of gas fired unit heaters
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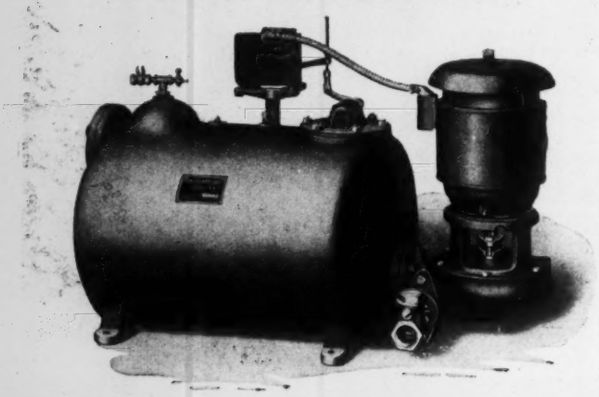
VERY LOW RETURN CONDENSATION PUMP AND RECEIVER



The Skidmore Condensation Pump is constructed to receive returns by gravity within a few inches of floor while the electric motor and control are placed high above danger of being submerged by flood. Cast iron tank and bronze fitted pump. Requires no bed plate and not necessary to be pitted on most jobs. Automatic in operation and requires no attention.

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A busy little unit for a hot job.

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The Internal Cleanser for Either New or Old Heating Systems

VINCO removes oil, grease, rust, scale, dirt, stops priming, foaming, surging, sluggish steaming and fuel waste.

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Use Vinco whenever you want to clean up a storage tank. It will assure the user of clean, sparkling water free from rust and scale.

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QUALITY HEATING SYSTEMS

Barnes & Jones

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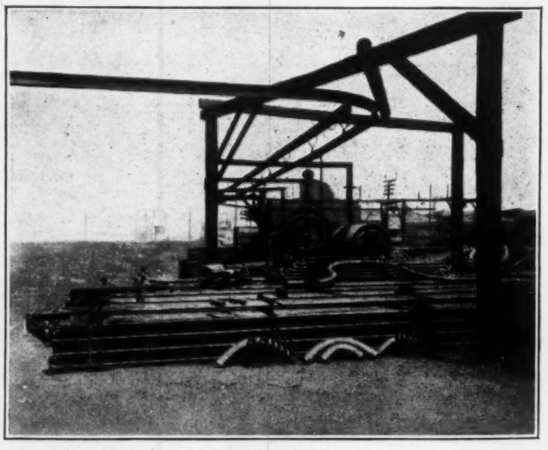
Modulation Vapor and Vacuum Heating Systems of Proven Quality

ESTABLISHED 1880



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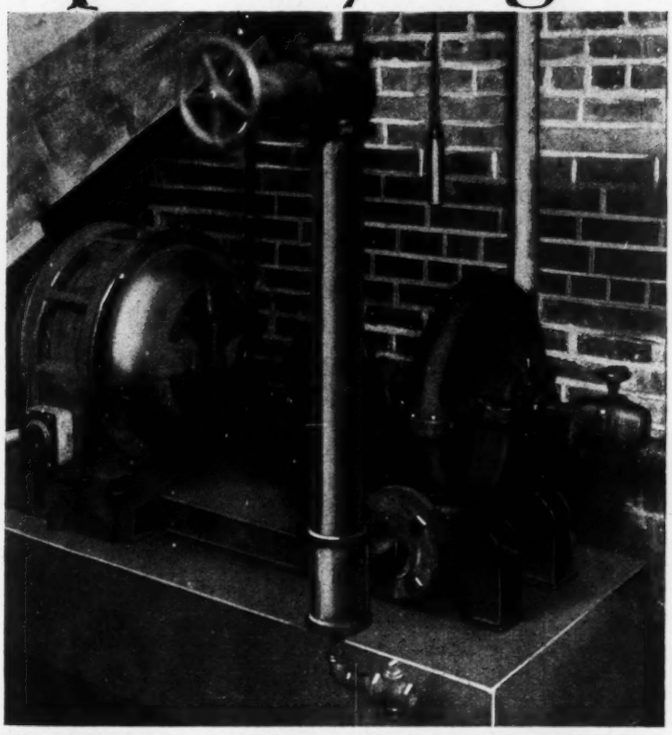

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Plants where four, five and sometimes more different makes of pumps are in use, have not had, as a general rule, very good service from any of them.

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There is a Buffalo pump for every purpose. Users testify to their long life and reliability. Why not ask for our complete binder for your files.

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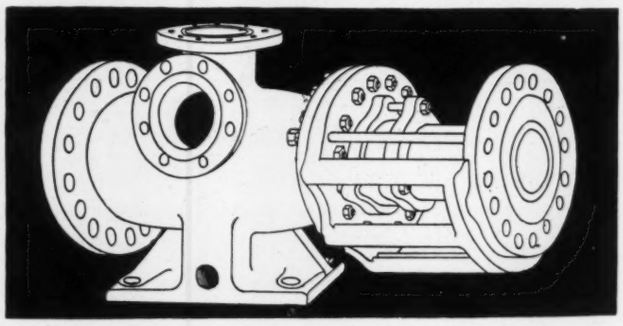

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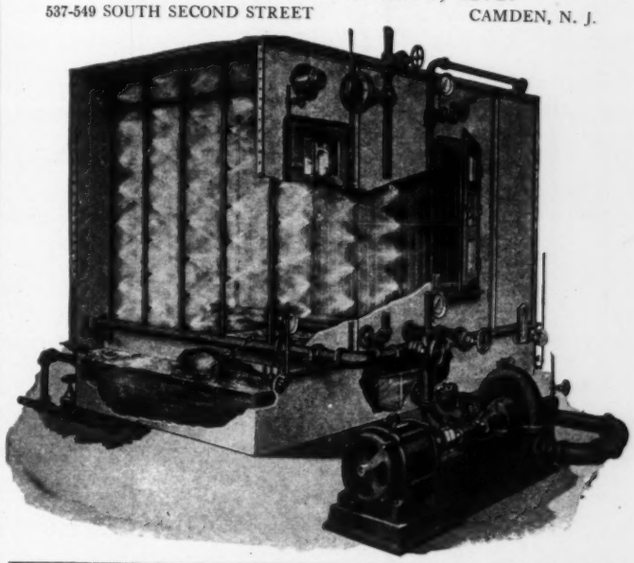

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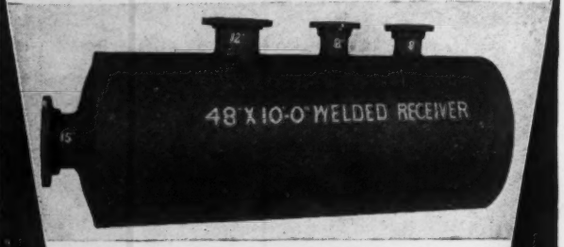

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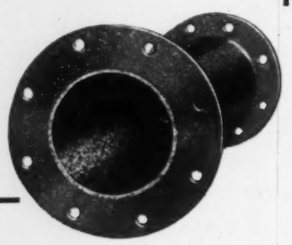

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(See Systems)

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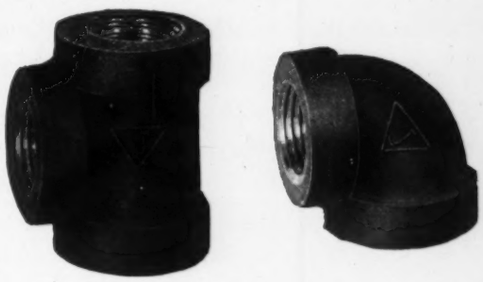

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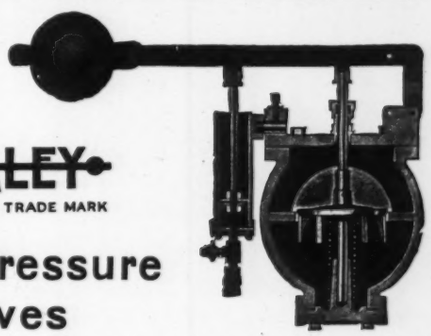

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Dunham Co., C. A., Chicago, Ill.
Hoffman Specialty Co., Waterbury, Connecticut
Nash Engineering Co., So. Norwalk, Conn.
Skidmore Corp., Chicago, Ill.
Trane Co., La Crosse, Wis.

PUMPS, CONDENSATION
American Steam Pump Co., Battle Creek, Mich.
Ames Pump Co., New York City
Buffalo Steam Pump Co., Buffalo
Dunham Co., C. A., Chicago, Ill.
Hoffman Specialty Co., Waterbury, Conn.
Nash Engineering Co., So. Norwalk, Conn.
Skidmore Corp., Chicago, Ill.
Trane Co., La Crosse, Wis.

PUMPS, CONDENSATION AND RECEIVER COMBINED
American Steam Pump Co., Battle Creek, Michigan.
Ames Pump Co., New York City
Buffalo Steam Pump Co., Buffalo
Dunham Co., C. A., Chicago, Ill.
Hoffman Specialty Co., Waterbury, Connecticut
Nash Engineering Co., So. Norwalk, Conn.
Skidmore Corp., Chicago, Ill.
Sterling Engineering Co., Milwaukee, Wisconsin.
Trane Co., La Crosse, Wis.

PUMPS, CONTRACTORS
Nash Engineering Co., So. Norwalk, Conn.

PUMPS, DEEP WELL
American Steam Pump Co., Battle Creek, Mich.
Crane Co., Chicago

PUMPS, DRY VACUUM
American Steam Pump Co., Battle Creek, Mich.
Ames Pump Co., Inc., New York

PUMPS, FLAT BOX
Nash Engineering Co., So. Norwalk, Conn.

PUMPS, FUEL OIL
American Steam Pump Co., Battle Creek, Mich.

PUMPS, HYDRAULIC
American Steam Pump Co., Battle Creek, Mich.
Buffalo Steam Pump Co., Buffalo
Skidmore Corp., Chicago, Illinois.
Trane Co., La Crosse, Wis.

PUMPS, POWER
American Steam Pump Co., Battle Creek, Mich.

PUMPS, ROTARY
Nash Engineering Co., So. Norwalk, Conn.
Skidmore Corp., Chicago, Illinois.

PUMPS, SEWAGE
Nash Engineering Co., So. Norwalk, Conn.

PUMPS, SHALLOW WELL
Crane Co., Chicago.

PUMPS, STEAM
American Steam Pump Co., Battle Creek, Michigan.
Ames Pump Co., Inc., New York
Buffalo Steam Pump Co., Buffalo
Nash Engineering Co., So. Norwalk, Conn.

PUMPS, SUMP
American Steam Pump Co., Battle Creek, Mich.
Buffalo Steam Pump Co., Buffalo
Nash Engineering Co., So. Norwalk, Conn.

PUMPS, VACUUM
American Steam Pump Co., Battle Creek, Mich.
Ames Pump Co., New York City
Dunham Co., C. A., Chicago, Ill.
Hoffman Specialty Co., Waterbury, Connecticut
Nash Engineering Co., So. Norwalk, Conn.
Skidmore Corp., Chicago, Ill.

PUMPS, WATER CIRCULATING
American Steam Pump Co., Battle Creek, Michigan.
Ames Pump Co., Inc., New York
Buffalo Steam Pump Co., Buffalo
Nash Engineering Co., So. Norwalk, Conn.
Sterling Engineering Co., Milwaukee, Wis.
Trane Co., La Crosse, Wis.

RADIATOR BASES
(See Bases, Radiator)

RADIATOR HANGERS
(See Hangers or Brackets, Radiator)

RADIATORS, CABINET AND CONCEALED
Air-Way Electric Appliance Corp., Toledo, O.
Black Mfg. Co., Inc., J. C., Oil City, Pa.
Thermal Units Co., Chicago, Ill.
Trane Co., La Crosse, Wis.

RADIATORS, CABINET AND CONCEALED, GAS FIRED
Texo Heater & Mfg. Corp., Covington, Ky.

RADIATORS, CAST IRON
American Radiator Co., New York
Crane Co., Chicago, Ill.
Kewanee Boiler Corp., Kewanee, Ill.

RADIATORS, COPPER
Trane Co., La Crosse, Wis.
Winchester Repeating Arms Co., New Haven, Conn.

RADIATORS, INDIRECT
Air-Way Electric Appliance Corp., Toledo, O.
American Radiator Co., New York
Thermal Units Co., Chicago, Ill.
Trane Co., La Crosse, Wis.
York Heating & Ventilating Corp., Philadelphia, Pa.

RADIATORS, INDIRECT, CAST IRON
Winchester Repeating Arms Co., New Haven, Conn.

RADIATORS, INDIRECT, COPPER
Winchester Repeating Arms Co., New Haven, Conn.

RECEIVERS, AIR
Kewanee Boiler Corp., Kewanee, Ill.
Lehigh Fan & Blower Co., Allentown, Penna.
Nash Engineering Co., So. Norwalk, Conn.
Philadelphia Pipe Bending Co., Philadelphia.

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Crane Co., Chicago, Ill.
Hoffman Specialty Co., Waterbury, Connecticut
Illinois Engineering Co., Chicago
Nash Engineering Co., So. Norwalk, Conn.
Skidmore Corp., Chicago, Illinois.
Trane Co. La Crosse, Wis.

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Frank Heater & Eng. Co., O. E., Buffalo, N. Y.

REFRIGERATING APPARATUS
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Pennsylvania Engineering Co., Philadelphia, Pa.
Vilter Mfg. Co., Milwaukee.
York Heating & Ventilating Corp., Philadelphia, Pa.
Zanesville Engineering Co., Zanesville, O.

REFRIGERATION, CENTRIFUGAL
Carrier Engineering Corp., Newark, N. J.

REGULATORS, BOILER FEED
(See Governors, Boiler Feed)

REGULATORS, DAMPER
American District Steam Co., No. Tonawanda, N. Y.
American Radiator Co. New York
Crane Co., Chicago, Ill.
Dunham Co., C. A., Chicago, Ill.
Hoffman Specialty Co., Waterbury, Connecticut
Illinois Engineering Co., Chicago
Marsh & Co., Jas. P., Chicago
McAlear Mfg. Co., Chicago, Ill.
National Regulator Co., Chicago
Powers Regulator Co., Chicago, Ill.
Sarco Co., Inc., New York City
Sterling Engineering Co., Milwaukee, Wis.
Trane Co., La Crosse, Wis.
Warren Webster & Co., Camden, New Jersey

REGULATORS, HUMIDITY
American Moistening Co., Providence, R. I.
Carrier Engineering Corp., Newark, N. J.
Grinnell Co., Inc., Providence, R. I.
Johnson Service Co., Milwaukee
National Regulator Co., Chicago
Parks-Cramer Co.,Fitchburg,Mass.
Powers Regulator Co., Chicago, Ill.
Zephyr Washed Air Co., Minneapolis, Minnesota.

REGULATORS, PRESSURE
American District Steam Co., No. Tonawanda, N. Y.
American Radiator Co., New York
Crane Co., Chicago, Ill.
Dunham Co., C. A., Chicago, Ill.
Illinois Engineering Co., Chicago
Marsh & Co., Jas. P., Chicago
McAlear Mfg. Co., Chicago, Ill.
Oxweld Acetylene Co., New York
Trane Co., La Crosse, Wis.

REGULATORS, PRESSURE, FOR OXY-ACETYLENE WELDING AND CUTTING
Air Reduction Sales Co., New York

REGULATORS, ROOM TEMPERATURE
American Radiator Co., New York
Johnson Service Co., Milwaukee
Marsh & Co., Jas. P., Chicago
National Regulator Co., Chicago
Powers Regulator Co., Chicago
Sarco Co., Inc., New York City
Stat-Amatic Instrument and Appliance Co., Hartford, Conn.
Sterling Engineering Co., Milwaukee, Wis.

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American Radiator Co., New York
Illinois Engineering Co., Chicago
Johnson Service Co., Milwaukee
Marsh & Co., Jas. P., Chicago
National Regulator Co., Chicago
Powers Regulator Co., Chicago
Sarco Co., Inc., New York City

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Sturtevant Co., B. F., Boston
York Heating & Ventilating Corp., Philadelphia, Pa.

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Pennsylvania Engineering Co., Philadelphia, Penna.

RODS, WELDING
Quasi-Arc Inc., New York City.

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Dresser Mfg. Co., S. R. Bradford, Pa.

SAWS, HACK
Crane Co., Chicago.
Excelso Products Corp., Buffalo.

SEPARATORS, AIR
Crane Co., Chicago
Illinois Engineering Co., Chicago

SEPARATORS, AMMONIA
Vilter Mfg. Co., Milwaukee.

SEPARATORS, OIL
Crane Co., Chicago, Ill.
Illinois Engineering Co., Chicago
McAlear Mfg. Co., Chicago, Ill.
Warren Webster & Co., Camden, New Jersey

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Crane Co., Chicago, Ill.
Illinois Engineering Co., Chicago
McAlear Mfg. Co., Chicago, Ill.
Power Piping Co., Pittsburgh
Sims Co., The, Erie, Penna.
Warren Webster & Co., Camden, N. J.

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Ilg Electric Ventilating Co., Chicago, Ill.

SHUTTERS, AUTOMATIC OR MANUAL FOR VENTILATING
National Regulator Co., Chicago.

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Dresser Mfg. Co., S. R. Bradford, Pa.
Knowles Pipe Sleeve Co., New York City

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SOFTENINGS, WATER, AUTOMATIC
Crane Co., Chicago.

SPRAY COOLING SYSTEMS
(See Systems)

SPRAY NOZZLES
(See Nozzles, Spray)

SPRINKLER HEADS
(See Heads, Sprinkler)

STEAM COCKS
(See Cocks, Steam)

STOCKS AND DIES
Crane Co., Chicago, Ill.

STRAINERS, STEAM
Illinois Engineering Co., Chicago
McAlear Mfg. Co., Chicago, Ill.
Sarco Co., Inc., New York City
Sterling Engineering Co., Milwaukee, Wisconsin.
Warren Webster & Co., Camden, N. J.

STRAINERS, WATER
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Illinois Engineering Co., Chicago
McAlear Mfg. Co., Chicago, Ill.
McDonnell & Miller, Chicago
Sarco Co., Inc., New York City
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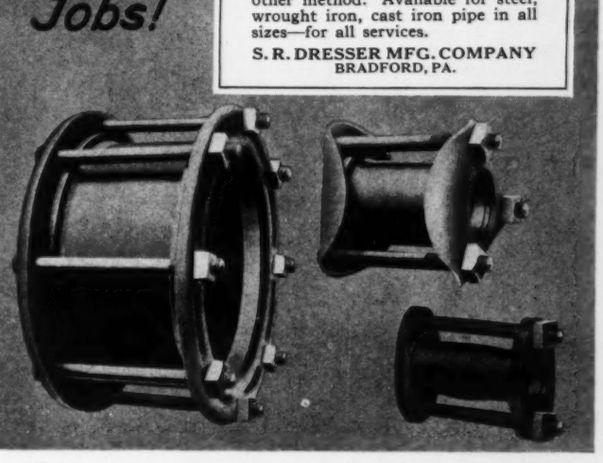

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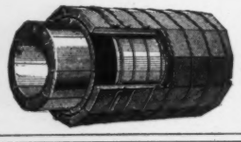

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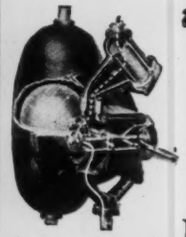

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Grinnell Co., Inc., Providence, R. I.
Ilg Electric Ventilating Co., Chicago, Illinois.
Maryland Air Conditioning Corp., Baltimore, Md.
Midwest Mfg. Co., Inc., Bradford, Pa.
National Regulator Co., Chicago
Parks-Cramer Co., Fitchburg, Mass.
Reed Air Filter Co., Inc., Louisville, Ky.
Sturtevant Co., B. F., Boston
Texo Heater & Mfg. Corp., Covington, Ky.
York Heating & Ventilating Corp., Philadelphia, Penna.
Zephyr Washed Air Co., Minneapolis, Minnesota.

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Carrier Engineering Corp., Newark, N. J.
Clarage Fan Co., Kalamazoo, Mich.
Ilg Electric Ventilating Co., Chicago, Ill.
Pennsylvania Engineering Co., Philadelphia, Pa.
Sturtevant Co., B. F., Boston
Texo Heater & Mfg. Corp., Covington, Ky.
Thermal Units Co., Chicago, Ill.
Vilter Mfg. Co., Milwaukee.
York Heating & Ventilating Corp., Philadelphia, Pa.

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Carrier Engineering Corp., Newark, N. J.
Clarage Fan Co., Kalamazoo, Mich.
Ilg Electric Ventilating Co., Chicago, Ill.
Sturtevant Co., B. F., Boston
Trane Co., La Crosse, Wis.
York Heating & Ventilating Corp., Philadelphia, Pa.

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Buffalo Forge Co., Buffalo, N. Y.
Carrier Engineering Corp., Newark, New Jersey
Clarage Fan Co., Kalamazoo, Mich.
Ilg Electric Ventilating Co., Chicago, Ill.
Sturtevant Co., B. F., Boston
Texo Heater & Mfg. Corp., Covington, Ky.
York Heating & Ventilating Corp., Philadelphia, Pa.
Zephyr Washed Air Co., Minneapolis, Minnesota.

SYSTEMS, DUST COLLECTING

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Buffalo Forge Co., Buffalo, N. Y.
Clarage Fan Co., Kalamazoo, Mich.
Ilg Electric Ventilating Co., Chicago, Illinois.
Midwest Mfg. Co., Inc., Bradford, Pa.
Reed Air Filter Co., Inc., Louisville, Ky.
Sturtevant Co., B. F., Boston

SYSTEMS, EXHAUST

Buffalo Forge Co., Buffalo, N. Y.
Clarage Fan Co., Kalamazoo, Mich.
Ilg Electric Ventilating Co. Chicago, Ill.
Sturtevant Co., B. F., Boston

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Texo Heater & Mfg. Corp., Covington, Ky.

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Buffalo Forge Co., Buffalo, N. Y.
Clarage Fan Co., Kalamazoo, Mich.
Ilg Electric Ventilating Co., Chicago, Illinois.
Sturtevant Co., B. F., Boston
York Heating & Ventilating Corp., Philadelphia, Pa.

SYSTEMS, HEATING, DIFFERENTIAL VACUUM

Dunham Co., C. A., Chicago, Ill.

SYSTEMS, HEATING, DISTRICT

Black Mfg. Co., Inc., J. C., Oil City, Pa.

SYSTEMS, HEATING, RETURN

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Marsh & Co., Jas. P., Chicago

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Ames Pump Co., New York City.
Barnes & Jones, Jamaica Plain, Massachusetts
Crane Co., Chicago, Ill.
Dunham Co., C. A., Chicago, Ill.
Hoffman Specialty Co., Waterbury, Conn.
Illinois Engineering Co., Chicago
Marsh & Co., Jas. P., Chicago
McAlear Mfg. Co., Chicago, Ill.
Nash Engineering Co., So. Norwalk, Conn.
Sarco Co., Inc., New York City
Sterling Engineering Co., Milwaukee, Wis.
Trane Co., La Crosse, Wis.
Warren Webster & Co., Camden, N. J.

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American District Steam Co., North Tonawanda, New York
Barnes & Jones, Jamaica Plain, Massachusetts
Trane Co., Chicago, Ill.
Dunham Co., C. A., Chicago, Ill.
Hoffman Specialty Co., Waterbury, Conn.
Illinois Engineering Co., Chicago
Marsh & Co., Jas. P., Chicago
McAlear Mfg. Co., Chicago, Ill.
Sarco Co., Inc., New York City.
Sterling Engineering Co., Milwaukee, Wis.
Trane Co., La Crosse, Wis.
Warren Webster & Co., Camden, N. J.

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Crane Co., Chicago, Ill.
Frank Heater & Eng. Co., Inc., O. E., Buffalo, N. Y.
Nash Engineering Co., So. Norwalk, Conn.

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Zanesville Engineering Co., Zanesville, O.

SYSTEMS, ICE WATER COOLING

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Ric-wil Company, Cleveland, O.

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SYSTEMS, SPRAY COOLING

Buffalo Forge Co., Buffalo, N. Y.
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SYSTEMS, STEAM DRAINAGE AND BOILER FEEDING

Morehead Mfg. Co., Detroit, Mich.

SYSTEMS, TEMPERATURE CONTROL

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Carrier Engineering Corp., Newark, New Jersey
Illinois Engineering Co., Chicago
Johnson Service Co., Milwaukee

Marsh & Co., Jas. P., Chicago, Ill.
National Regulator Co., Chicago
Powers Regulator Co., Chicago
Sarco Co., Inc., New York
Sterling Engineering Co., Milwaukee, Wisconsin.

SYSTEMS, VENTILATING

Air-Way Electric Appliance Corp., Toledo, O.
Buffalo Forge Co., Buffalo, N. Y.
Carrier Engineering Corp., Newark, New Jersey
Clarage Fan Co., Kalamazoo, Mich.
Ilg Electric Ventilating Co., Chicago, Illinois.
National Regulator Co., Chicago
Sturtevant Co., B. F., Boston
Texo Heater & Mfg. Corp., Covington, Ky.
Wing Mfg. Co., L. J., New York
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Gerstein & Cooper Co., So. Boston
Lehigh Fan & Blower Co., Allentown, Penna.

TANKS, AIR OR GAS

Lehigh Fan & Blower Co., Allentown, Penna.

TANKS, AMMONIA

Vilter Mfg. Co., Milwaukee.

TANKS, COPPER

Gerstein & Cooper Co., So. Boston

TANKS, EXPANSION

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TANKS, FILTER

Sims Co., The, Erie, Pennsylvania

TANKS, PRESSURE

Gerstein & Cooper Co., So. Boston
Sims Co., The, Erie, Penna.

TANKS, RECEIVER

Sims Co., The, Erie, Penna.
Warren Webster & Co., Camden, N. J.
Zanesville Engineering Co., Zanesville, O.

TEMPERATURE CONTROL

(See Systems, Temperature Control)

THERMOMETERS, INDICATING AND RECORDING

(See Instruments, Indicating and Recording)

THERMOSTATS

(See Regulators, Room Temperature)

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Marley Co., The, Kansas City, Mo.
Zanesville Engineering Co., Zanesville, O.

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Vilter Mfg. Co., Milwaukee.

TRAPS, BLAST

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American Radiator Co., New York
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Crane Co., Chicago, Ill.
Dunham Co., C. A., Chicago, Ill.
Fairbanks Co., The, New York
Hoffman Specialty Co., Waterbury, Conn.
Illinois Engineering Co., Chicago
Marsh & Co., Jas. P., Chicago, Ill.
McAlear Mfg. Co., Chicago, Ill.
Sarco Co., Inc., New York City
Sterling Engineering Co., Milwaukee, Wis.
Warren Webster & Co., Camden, N. J.

TRAPS, RADIATOR

(See Valves, Radiator Return Line)

TRAPS, STEAM

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Barnes & Jones, Jamaica Plain, Massachusetts
Crane Co., Chicago, Ill.
Dunham Co., C. A., Chicago, Ill.
Hoffman Specialty Co., Waterbury, Conn.
Illinois Engineering Co., Chicago
Marsh & Co., Jas. P., Chicago, Ill.
McAlear Mfg. Co., Chicago, Ill.
Powers Regulator Co., Chicago
Sarco Co., Inc., New York City
Trane Co., La Crosse, Wis.
Warren Webster & Co., Camden, N. J.

TRAPS, VACUUM

Barnes & Jones, Jamaica Plain, Massachusetts
Crane Co., Chicago, Ill.
Illinois Engineering Co., Chicago
Marsh & Co., Jas. P., Chicago, Ill.
McAlear Mfg. Co., Chicago, Ill.
Sarco Co., Inc., New York City
Sterling Engineering Co., Milwaukee, Wis.
Trane Co., La Crosse, Wis.
Warren Webster & Co., Camden, N. J.

TUBE COUPLINGS

(See Couplings, Tube)

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Reading Iron Co., Reading, Pa.

TUBING, BRASS AND COPPER

Crane Co., Chicago, Ill.
Wolverine Tube Co., Detroit, Mich.

TURBO BLOWERS

(See Blowers, Turbo)

UNIT HEATERS

(See Heaters, Unit)

UNIT VENTILATORS

(See Ventilators, Unit)

VACUUM CLEANING APPARATUS

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Sturtevant Co., B. F., Boston

VALVES, AIR LINE

Hoffman Specialty Co., Waterbury, Conn.
Marsh & Co., Jas. P., Chicago

VALVES, AIR RELIEF

American Radiator Co., New York
Crane Co., Chicago, Ill.
Dunham Co., C. A., Chicago, Ill.
Marsh & Co., Jas. P., Chicago, Ill.
McAlear Mfg. Co., Chicago, Ill.
Trane Co., La Crosse, Wis.

VALVES, ALARM FOR SPRINKLER SYSTEMS

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Grinnell Co., Inc., Providence, R. I.

VALVES, ANGLE, GLOBE AND CROSS

Crane Co., Chicago, Ill.
Fairbanks Co., The, New York.
Grinnell Co., Inc., Providence, R. I.
Vilter Mfg. Co., Milwaukee.

VALVES, BACK PRESSURE

Crane Co., Chicago, Ill.
Illinois Engineering Co., Chicago.
Kieley & Mueller, Inc., New York City.
McAlear Mfg. Co., Chicago, Ill.
Oxweld Acetylene Co., New York.
Vilter Mfg. Co., Milwaukee.

VALVES, BALANCED

Crane Co., Chicago, Ill.
Illinois Engineering Co., Chicago
McAlear Mfg. Co., Chicago, Ill.
Vilter Mfg. Co., Milwaukee.

VALVES, BLOW-OFF

Crane Co., Chicago, Ill.
Fairbanks Co., The, New York

VALVES, BOILER FEED

Crane Co., Chicago, Ill.
Fairbanks Co., The, New York
McAlear Mfg. Co., Chicago, Ill.
McDonnell & Miller, Chicago

VALVES, CHECK

Crane Co., Chicago, Ill.
Dunham Co., C. A., Chicago, Ill.
Fairbanks Co., The, New York
Vilter Mfg. Co., Milwaukee.

VALVES, CONTROL FOR SPRINKLER SYSTEMS

Crane Co., Chicago, Ill.
Fairbanks Co., The, New York
Grinnell Co., Inc., Providence, R. I.

VALVES, DIAPHRAGM

National Regulator Co., Chicago
Powers Regulator Co., Chicago

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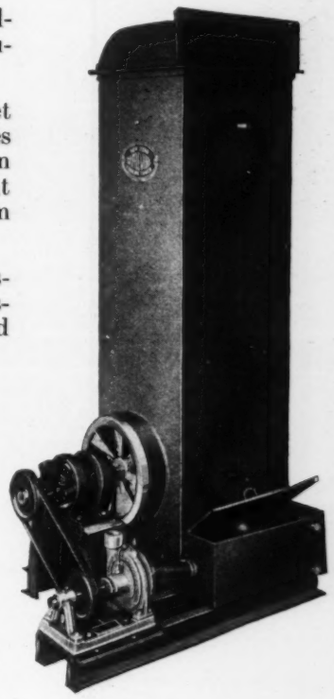

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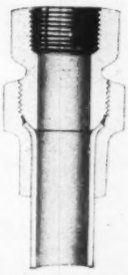

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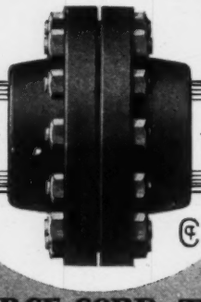

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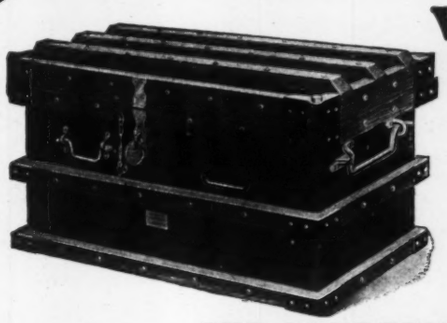

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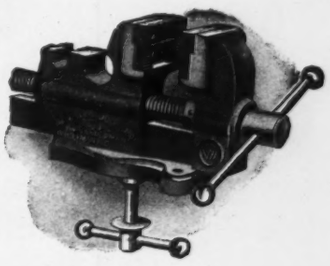

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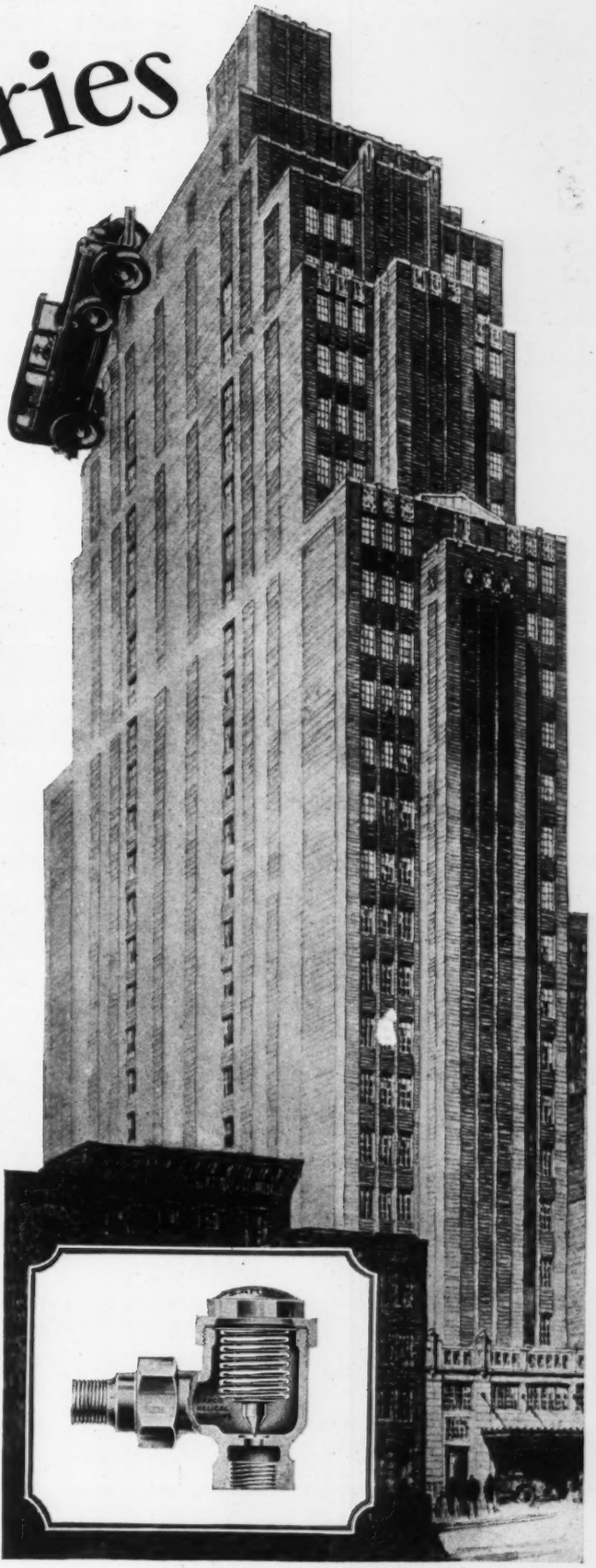

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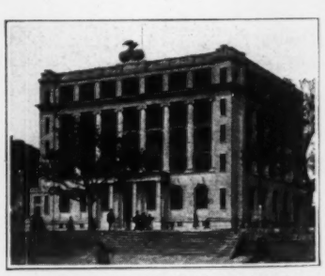

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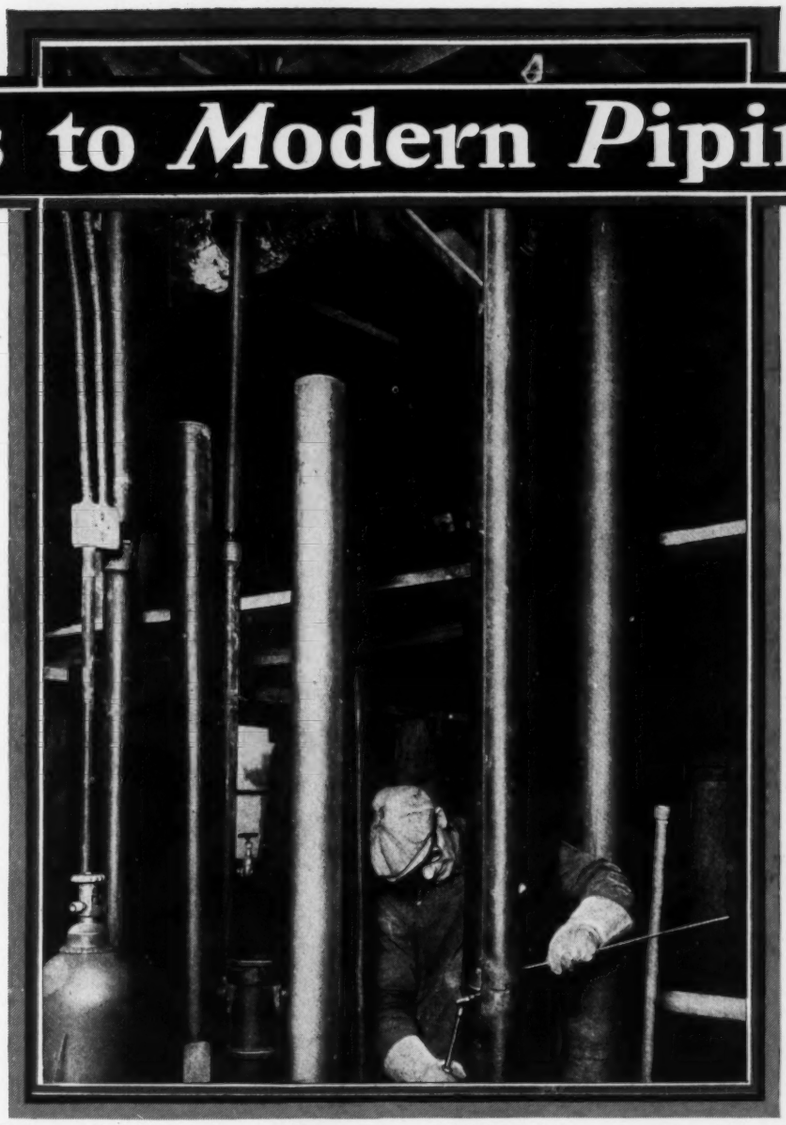

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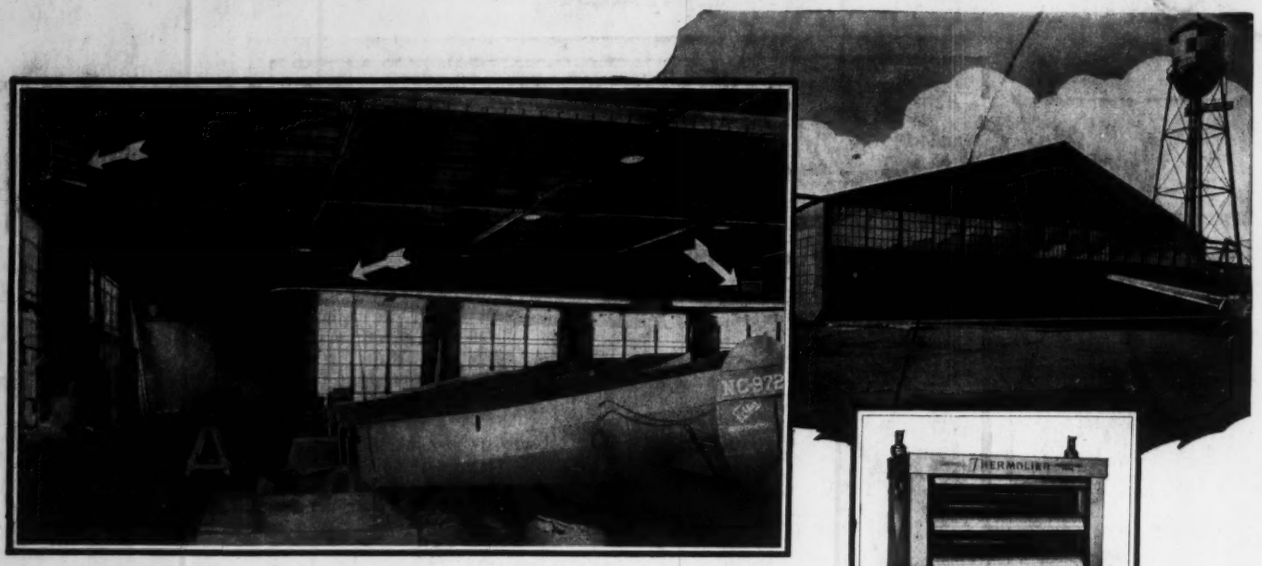

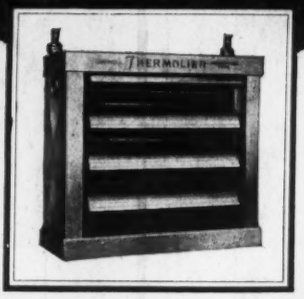

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